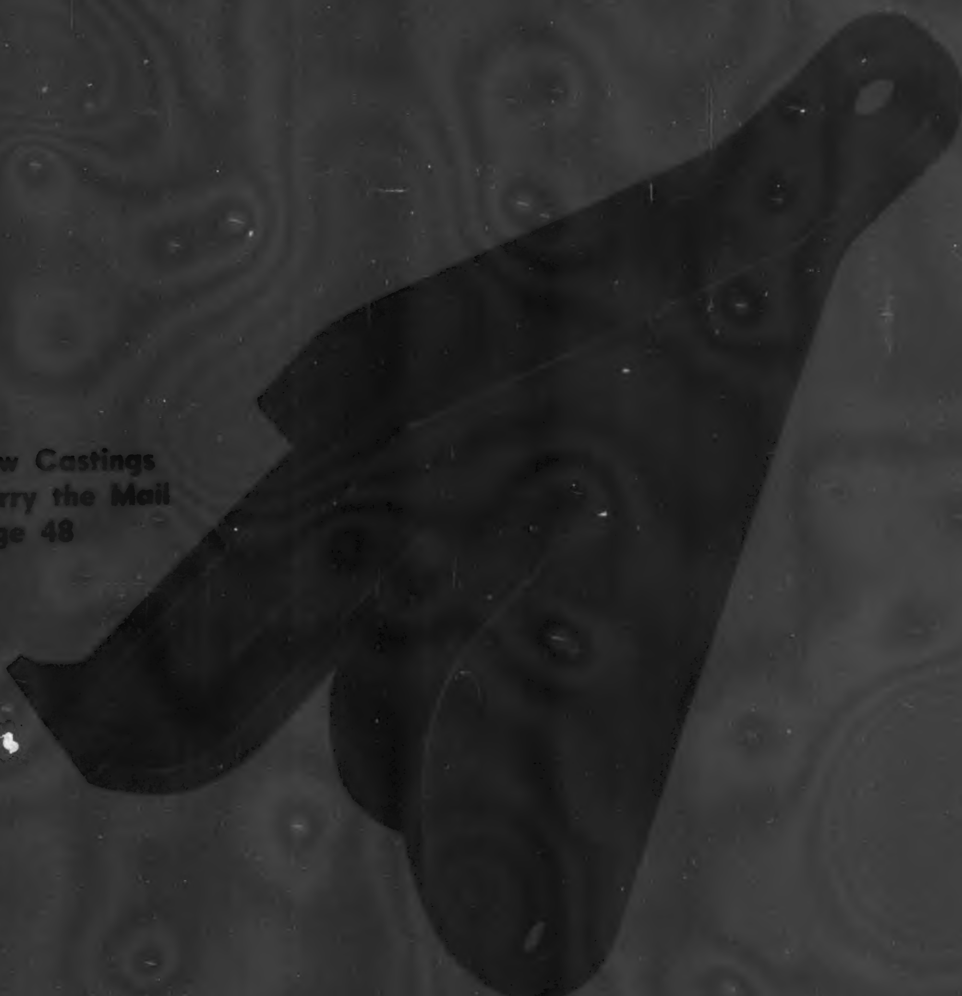
APRIL 1961

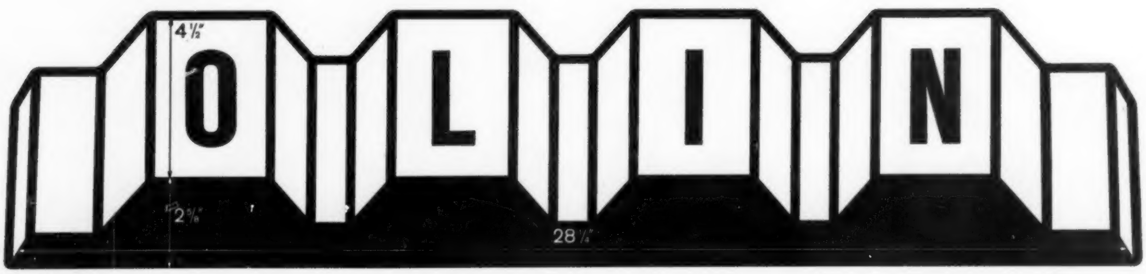
modern castings

THE TECHNOLOGY-FOR-PROFIT MAGAZINE

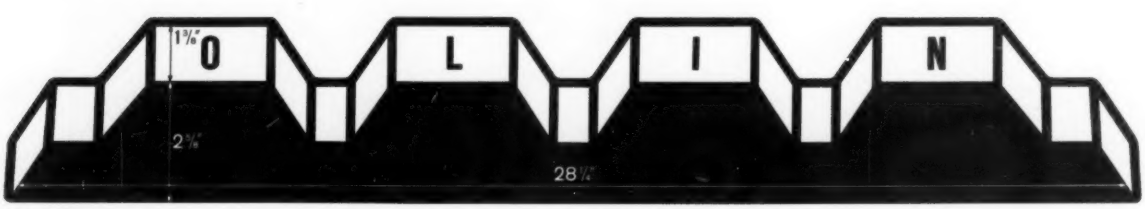


How Castings Carry the Mail Page 48

50-lb. ingot



25-lb. ingot



10-lb. ingot

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metalcasting "technology-for-profit"

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GENERAL MANAGER
WM. W. MALONEY

Let's look at . . .

1961's MOST IMPORTANT EVENT . . .
AND OUR MAY CONVENTION ISSUE

H. E. Green

NEXT MONTH the *most important event of 1961* for metalcasters will take place in San Francisco. It's the 65th Castings Congress of AFS. In my opinion, the American Foundrymen's Society has been the most constructive, unifying and key leadership force in the metalcasting industry. Some may forget this occasionally. Industry growth, length of service to a field, and the natural development of specialized interests all tend to diffuse and scatter aims and activities of individuals. This is the price of progress in an industry—and metalcasting is no exception. But the fact remains that AFS is still growing, that it continues to lead the way to all-industry improvement, and that its technical program is producing more profits and market opportunities for metalcasters than ever before!

Ample proof of market opportunities being developed today can be found on page 35 of this issue. There you'll find the beginning of a special, timely 10-page report on Aerospace developments. And on pages 57, 62, 72, and 85, you'll find four significant and exclusive technological reports on research conducted by AFS itself.

For cues to more technology-for-profit information look at pages 106 to 112. There you'll find the program of the 65th Castings Congress, May 8-12.

There's a *companion* event to this most important event of 1961. It's the May Convention issue of MODERN CASTINGS—*THE peak-interest* issue of the year of *any* publication in the field. In the May issue you'll find interpretative, copyrighted summaries of 100 "breakthroughs" in metalcasting.

These are PREVIEWS from the technological advances to be presented at the Congress. You'll get this news *first* and *exclusively* in MODERN CASTINGS. Also, you'll find other exclusive features as well. It will be a news and reference issue you will want to save for a long time. In fact, the 65th Castings Congress, and the May Convention issue of MODERN CASTINGS are two events worth the time and attention of everyone in metalcasting. Both are designed for all concerned with jobs and profits in the metalcasting industry. And MODERN CASTINGS is the one *official* reporting medium for the American Foundrymen's Society and its 65th Castings Congress. See you there!

Harold E Green

Looking at Business with Modern Castings

TIME FOR DECISION

There is every indication that April and May will be important decision-making months. An upturn in business conditions generally is expected. Metalcasters must be poised for action. Right now what they must determine is how much and how fast.

Although some companies are displaying a tendency to hold back (because of obvious risk factors), there is general agreement that the industry must move in quickly with product development and marketing programs designed to capitalize on every marketing opportunity.

Fortunately, there are three valuable guideposts now available:

1. The 100 or so top technological breakthroughs of 1961. (Interpretative summaries will be published first and exclusively in the May Convention issue of MODERN CASTINGS; and these will be followed by detailed presentations at the 65th Castings Congress in San Francisco.) The breakthroughs will lay the foundation for product and process strategy the rest of this year.

2. Current conditions in the end-use industries served by metalcasters. A careful examination of reports by reputable business and marketing experts will help here. Here again marketing plans and technological developments will have a pronounced effect on what metalcasters plan and do.

3. An evaluation of metalcasting trends today by key executives in the industry. Here the correlation of the three guideposts becomes exceptionally significant: evaluation by bellwether executives. The Metalcasting Trends Panel will provide this. The first and exclusive report will be in the May Convention issue of MODERN CASTINGS.

After all, technology IS profits! It provides the profitable difference over competitors within and without the industry. The Metalcasting Trends Panel will help metalcasting executives decide how much they will do how fast.

Naturally, there is a widespread interest in business conditions generally. The consensus is that an upturn is in the making —and even Secretary of Labor Goldberg is taking a more optimistic view, politics not withstanding.

There will be the traditional lag in re-employment: hours of work lengthening at first, and alternating work weeks ending.

Either overlooked or ignored by Mr. Goldberg seems to be the fact that when seasonable adjustments are applied to the employment situation the decline is less than 1 per cent. An unemployment problem existed before the recession set in last summer. This points to a sturdier economic base that most government experts are willing to admit.

LOOKING AT BUSINESS

Favorable signs which affect the metalcasting industry include such elements as:

1. Stocks: The Dow-Jones Industrial Stocks Index continues to go up as do other market indicators.
2. Construction: Home building is increasing—and construction of private buildings is still strong (office buildings, plants, etc.)
3. Prices: There's more strength in many markets, including durables.
4. Steel: Gains are being made, although the pace could be faster and more pronounced. There's a cautiousness here.
5. New Car Sales: A seasonal rise is taking place. Demand should be about at the same level as a year ago.
6. Business Investment: New plant and equipment expenditures for business this year (capital outlay) will be more than first anticipated. Only a 3 per cent decline from 1960 is predicted. Compare this to a 17 per cent drop in the 1958 recession, and you get a better perspective of current business conditions.

Far from the primary metals basis, but certainly an important factor in the economy, is increased activities on the retail level. People are spending more in department stores.

Coming back to metalcasting, the special preview of technology advancements to be announced in the May issue of MODERN CASTINGS takes on a new significance. (See page 107 this issue.) You can find and explore:

Commercial possibilities for lighter, thinner, but strong castings.

New techniques for lower cost operations, better quality control methods.

One fact stands out: The tempo of technological change is quickening. This means metalcasters must be more alert to changes in markets and market opportunities than ever before. And as mentioned before, today technology is creating profits where used quickly and expertly.

FERROUS SHIPMENTS

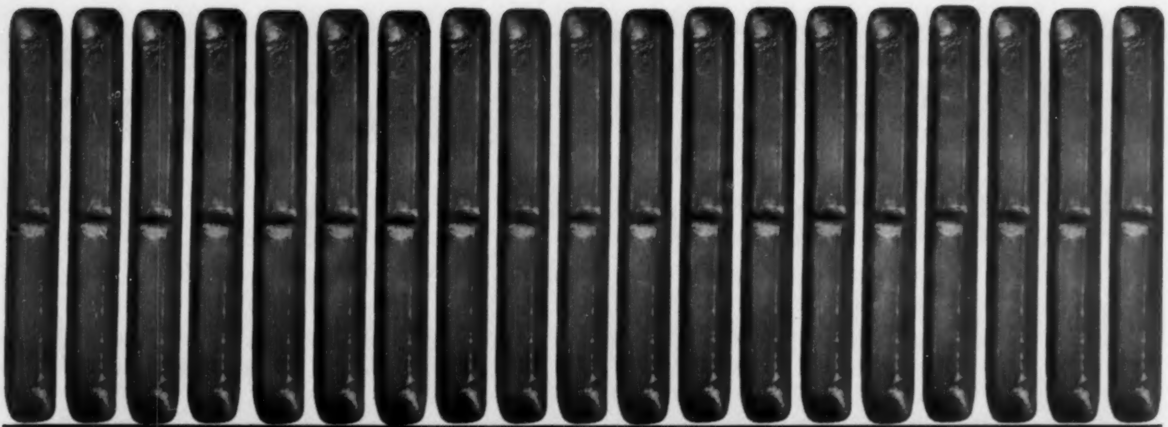
Shipments of steel castings showed a marked year-end improvement in December by running nine per cent above the November shipments. Total shipments ran to 108 thousand tons. The 1960 figure was still about 19 per cent short of shipments in 1959.

Shipments of gray iron castings in December amounted to 749 thousand short tons, a decline of about 10 per cent below November of 1960 and 32 per cent below December of 1959. Ductile iron castings shipments reached 12,097 short tons, an improvement over the 11,870 figure for November.

Malleable iron castings shipped in December totaled 57 thousand tons, a drop of nine per cent below the previous month.

NON-FERROUS SHIPMENTS

December shipments of non-ferrous castings totaled 164 million pounds, representing a decline of about seven per cent below the November figure. Total consisted of 53 million pounds of copper castings, 62 million pounds of aluminum castings, 46 million pounds of zinc castings, 1.9 million pounds of magnesium, and 1.3 million pounds of lead die castings.



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Around the World with Modern Castings

MOSCOW

One of the most complete compendiums of light metal foundry practices has just been translated into English by the Technical Information Center at Wright-Patterson Air Forces Base. Entitled "Handbook for the Foundry Worker—Shape Casting of Aluminum and Magnesium Alloys," the book presents the modern foundry techniques currently practiced in Russia. The 400 page handbook covers alloy systems, furnace charges, melting practices, molding materials, pouring, cleaning, heat treatment, die casting of both aluminum and magnesium base aloys. For light metal foundrymen interested in broadening their horizons in world-wide casting technology this book is recommended highly. Orders for the book may be placed through MODERN CASTINGS. (Price $6.50)

SWITZERLAND

The International Organization for Standardization announces that the ISO Brinell Hardness Test for Grey Cast Iron has been prepared and approved by the majority of ISO Member Bodies. It is now being submitted to the ISO Council for acceptance as an ISO recommendation. Any MODERN CASTING readers desirious of having a copy of this international test may have one by submitting a written request to the Editor.

The U. S. Task Force on International Standards Committee A-3 on Cast Iron is chairmanned by D. E. Krause, Gray Iron Research Institute. This committee is now working on a proposed International Classification of graphite in cast iron and impact testing of gray iron. It is encouraging to realize that foundry technology is surmounting the barriers of language and nationalism to bring forth international order and understanding.

CALIFORNIA

The Fluid Mold Casting process now makes it possible to produce smooth surfaced steel ingots in badly fire-checked molds. The process developed by National Supply Division of Armco Steel Corp., Torrence, Calif., utilizes a special slag which is melted and poured into bottom of ingot mold. As the molten steel rises in the mold the floating molten slag coats the wall as thin membrane. Pits, cavities, and cracks in mold wall are filled with slag to produce a smooth continuous mold coating. This coating imparts a smooth surface to the cast ingot, reduces ingot-to-billet conditioning costs, increases ingot mold life, and lowers refractory inclusion counts.

The FMC slag is melted in arc furnaces, heated to 3200 F, tapped into transfer ladle, and poured into mold in a quantity of 50 pounds per ton of gross ingot weight. Steel is poured immediately from bottom

pour lade. No slag entrapment during pouring has occurred. Foundrymen may give some thought to applying this technique in permanent mold casting to protect mold surfaces or in sand molds to improve refractoriness at mold-metal interface.

LONDON

Hollow zinc die castings can now be made using the Robar process. The cost of expensive retractable metal cores has been eliminated by drawing metal out of the partially solidified casting by suction. In the Robar process air is first evacuated from the die which is run cold for rapid metal chilling. Zinc is injected into die and within a fraction of a second the injection ram is sharply retracted. Design of gate and runner causes molten metal to be drawn out of mold cavity creating a hollow casting.

A typical application is the hollow metal heel used on ladies shoes. Other potential uses include hollow-cast gas-bottles and bodies for butane cigarette lighters. The bottles are seamless and withstand pressure up to 3000 psi. Higher pressures can be tolerated by increasing wall thickness with longer dwell time before suction stroke of ram. Also, wall thickness can be varied to sunt strength requirements by varying withdrawl rate of ram.

Hollow castings have been produced with wall thickness down to 0.020 inches and accuracies within 0.005 inches. New Markets will be opened for applications when external dimensions are somewhat massive but light weight is paramount to the point of tolerating completely hollow sections.

JAPAN

Precision casting of dies weighing over 3 tons has been disclosed by Toyo Kogyo Co., one of Japan's largest automobile manufacturers. In the period November 1959 to April 1960 this company has precision cast by the Shaw Process 100 cast iron shell molding patterns weighing as much as 44 pounds; 15 heat resistant steel die-casting dies with 600 pound maximum weight; 150 heat-resistant steel permanent molds weighing up to 11 pounds; and 200 cast iron press-tool punches and dies as large as 6200 pounds in weight.

In the process, CO_2 sand is first placed in the flask, then the ceramic slurry is poured in the space between the pattern and the CO_2 sand backing. This practice saves considerable in the quantities of slurry consumed. Although some finish machining must be performed on internal cavities before putting the dies into service, the overall savings in machining effected by casting the finished shape directly from molten metal are more than considerable.

USA

AFS-proposed ground rules to govern everyone concerned with industrial exhibits were discussed during March in Detroit at a meeting between AFS General Manager Wm. W. Maloney, AFS Exhibit & Convention Manager R. J. Hewitt, and members of the Detroit Civic Center Commission. The regulations were proposed for the 1962 Castings Congress & Exposition AFS plans to hold May 7-11 in Cobo Hall. The rules have already been adopted by the Teamsters Union and the Building Trades Council.

Reader Opinions and Ideas . . .

USING OLIVINE SAND

In the February MODERN CASTINGS article "New Sand Practices Produce Five-Way Profits," the mix is faced with 3 per cent air-set material, 14 per cent olivine sand, and 83 per cent 56 AFS sand (Silica).

We would like to know:

1. Is the silica sand dry?
2. Where is the olivine flour purchased?
3. What is the air-set material?
4. How soon after the mold making can you pour?

D.T.

Editor's Note: The sand is heap sand, purchased, washed and dried silica sand; used with a little bentonite to give a green strength of about 8 pounds and a moisture of 2 or 3 per cent. The olivine sand comes from the northwestern section and is purchased through a Chicago agent. The air set material is essentially a boiled oil, oil with metallic driers added. The molds are made one day and poured early the next. A minimum of 12 hours is allowed for setting. To pour sooner, molds can be dried by using air under 300 F. blown through the down sprue. However, some difficulty may come from over-baking or setting. The heat of the molten iron should accomplish the final hardness of the mold face.

MEETING SPECIFICATIONS

We are attempting to produce A-356 sand castings to Mil Spec C 21180 A (ASG) and, needless to say, we are having considerable difficulty in meeting the mechanical property requirements for Class I Casting as shown in table IV of specifications.

We can get tensiles that exceed specifications but the elongation is low. On the other hand, when we lower the magnesium content and/or reduce the aging time, we can get good elongation but not enough tensile strength.

G.S.

Editor's Note: The properties you are obtaining on alloy A356 when cast in sand are the properties which would be anticipated. Probably you

(Continued on page 23)

ENGINEERED BRONZES

Specify precisely alloyed, trouble-free,

Federated bronzes

Federated precisely engineered bronzes are produced by highly perfected alloying techniques and rigid quality control procedures developed at Asarco's Central Research Laboratories.

Result: Fewer rejects and more uniform castings. For best foundry performance, specify these high tensile bronzes:

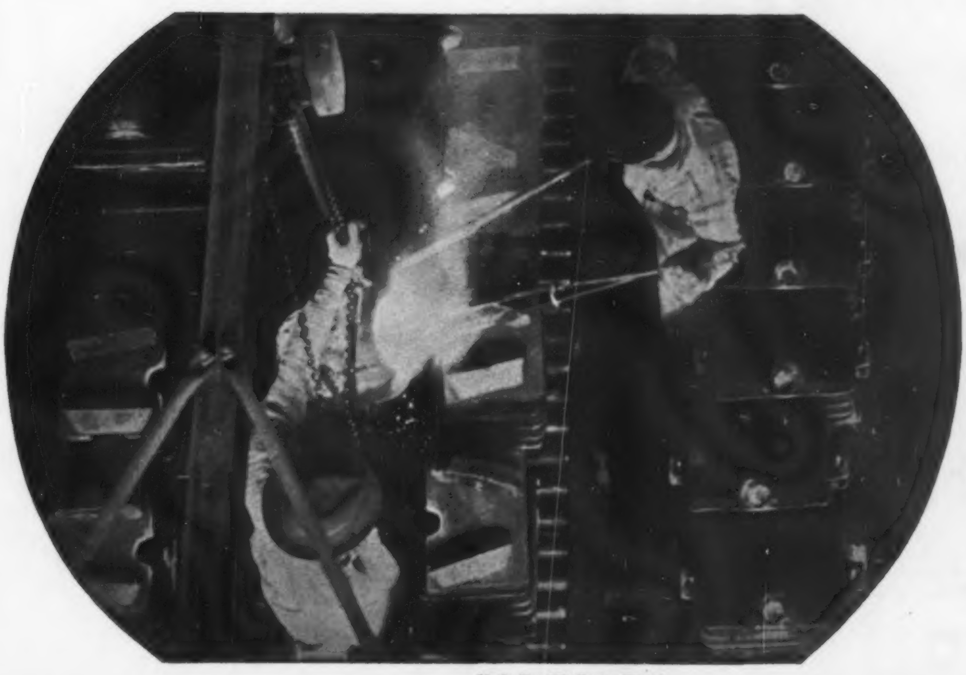
HERCULOY SILICON BRONZES — Tough — even among the toughest bronzes. Excellent fluidity, tensile strength up to 65,000 psi, yield strength up to 35,000 psi.

ALUMINUM BRONZES — Tensile strength as high as 120,000 psi after heat treatment.

MANGANESE BRONZES — As cast tensile strength up to 125,000 psi, exceptionally high hardness.

For complete data on these bronzes, write on your company letterhead for your copy of 60-page handbook "Brass and Bronze Casting Alloys." Write or call Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y., or your nearest Federated sales office.

ASARCO



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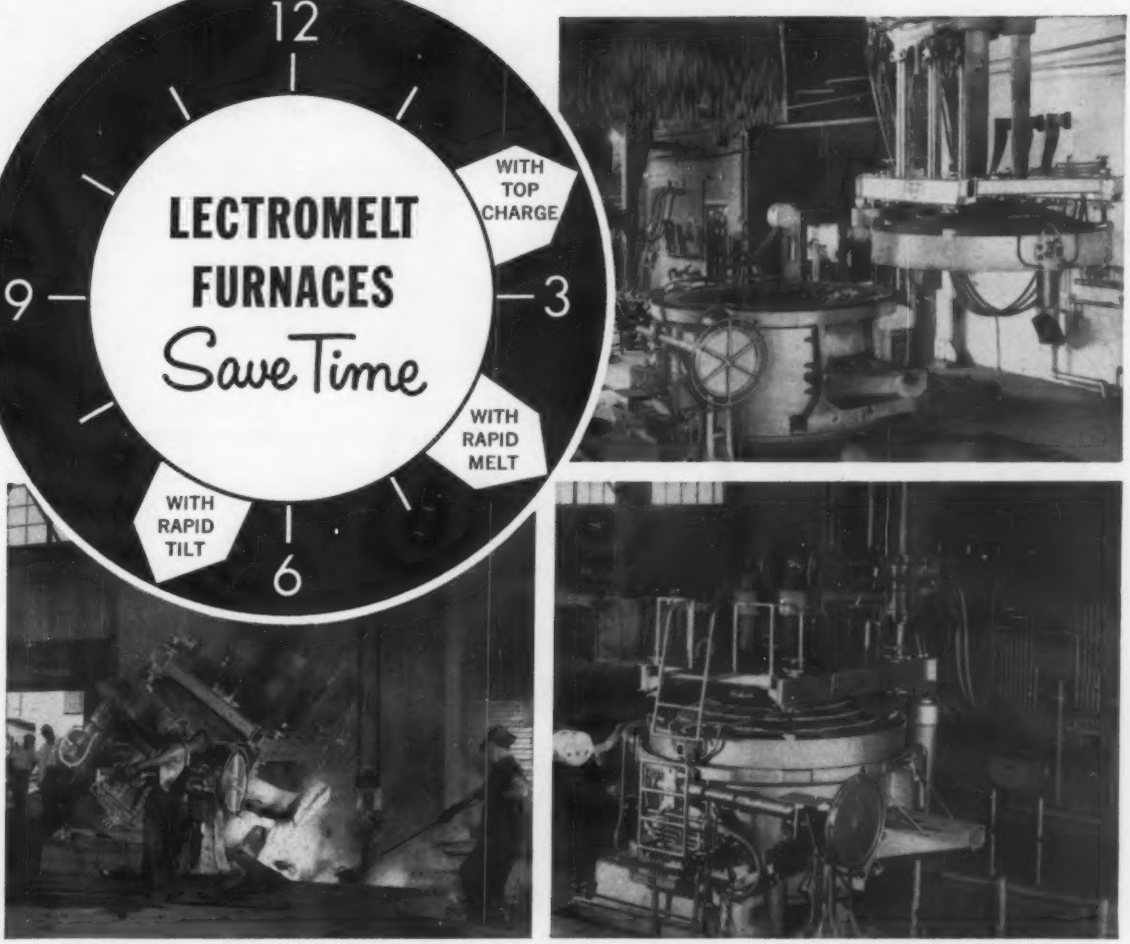

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HIGH POWER INPUT allows rapid metal melting. Lectromelt makes this possible with large transformers and leads, more efficient cooling and heavier furnace construction.

RAPID TILTING is accomplished smoothly and safely. Mechanism is accurate, strong and side-mounted—located out from under, where it won't get clogged by spillage.

Catalog 10 describes Lectromelt Furnaces. For a copy, write Lectromelt Furnace Division, McGraw-Edison Company, 316 32nd Street, Pittsburgh 30, Pennsylvania.

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McGRAW EDISON

Lectromelt

CANADA: Wild-Barfield Electric Furnaces, Ltd., Toronto... ITALY: Forni Stein, Genova... ENGLAND: G.W.B. Furnaces Limited, Dudley, Worcs.... SPAIN: General Electrica Espanola, Bilboa... FRANCE: Stein et Roubaix, Paris... BELGIUM: S. A. Stein & Roubaix, Bressoux-Liege... JAPAN: Daido Steel Co., Ltd., Nagoya

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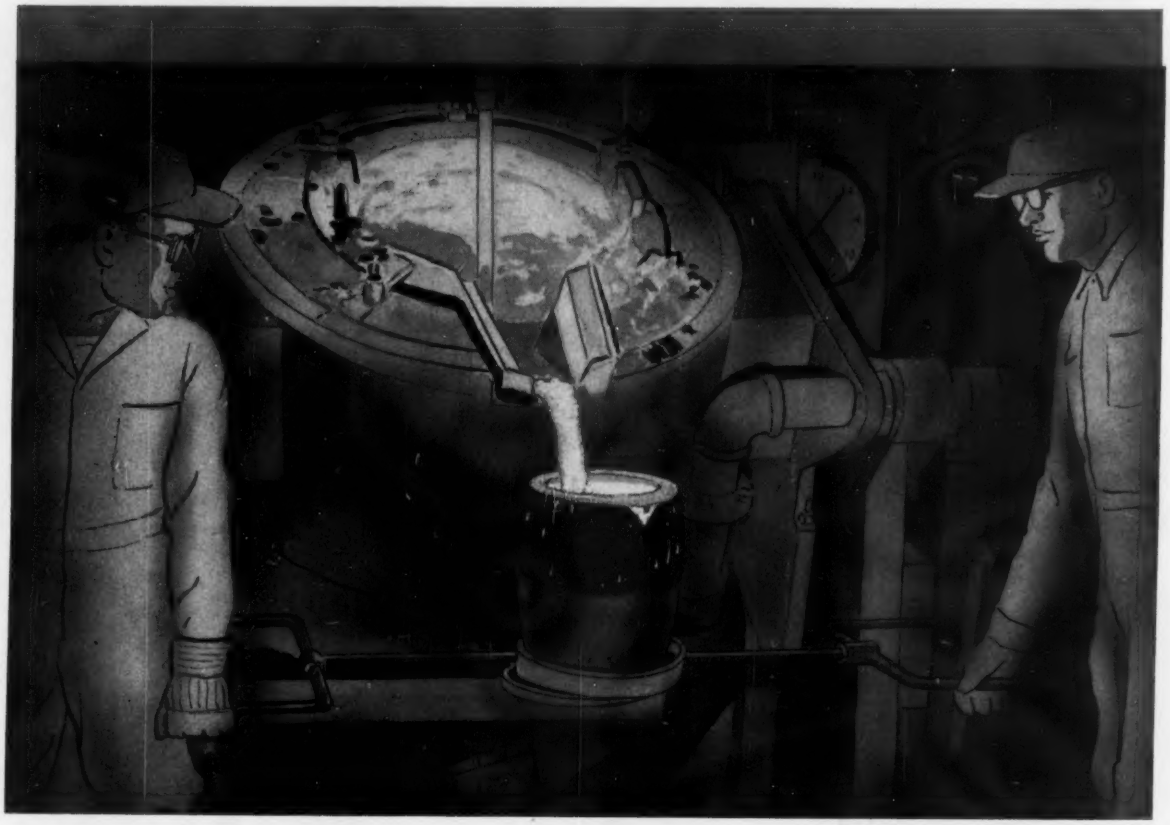


Continued from page 18

can not meet the requirements of these military specifications. The properties provided for in this specification can only be achieved if the alloy is cast in a permanent mold or special techniques are used such as chilling to cause rapid solidification. The specification was not originally prepared with the expectation that the properties required would be obtained in a sand casting.

OBSOLETE PATTERNS

Periodically our company is confronted with the question of retaining obsolete patterns in stock. Which should be destroyed and which should we continue to hold? Several different yardsticks have been used in making decisions on these points. However, in the interest of uniformity we are attempting to establish a policy governing scrapping obsolete patterns.

The two prime questions are:

1. How long a time, without usage, should a pattern be stored?
2. What factors such as replacement cost, casting usage, etc., other than time, go into a decision regarding scrapping?

W. L. G.

Editor's Note: There is no uniform policy practiced by the foundry industry regarding pattern retention. The length of time that a pattern should be retained in part depends upon the probable life of the castings and the obligation which your company might have to supply replacement castings on equipment sold at some prior time. In addition, retention of the pattern depends upon its condition and whether or not it is still usable. Patterns having little value or replacement cost deserve less consideration than costly ones.

USING SAND FOR FILL

Our company is promoting the use of used foundry and core sand for back fill on sewer, road, and other construction use. One of the objections offered by a municipal government is that the sand might corrode sewer pipe.

C. B. D.

Editor's Note: There is no reason to believe that there is any cause for concern over the use of either used foundry or core sand as back fill when laying cast iron sewer or pressure

water main. This material is 90-95 per cent silica sand plus such binders as bentonite, and in the case of cores, oil core binders. There is no reason why such materials should have any corrosive effect beyond that which might be expected in normal, good earth back fill.

SAFETY IMPROVEMENT

We are trying to improve our safety record. Would you please put us on your mailing list for pamphlets, ideas, or suggestions for better safety?

PERRY WHITE
Secretary-Treasurer
Hallman Foundry, Inc.
Sanford, N. C.

Editor's Note: We are enclosing our AFS book list indicating publications you should have for an effective safety program. In addition, AFS offers considerable assistance in other areas. MODERN CASTINGS *regularly carries safety ideas and articles. There is the AFS consulting service at no charge except cost of travel and transportation to your plant. In addition, the motion picture on eye protection called "It's Up To You" is available at no charge except cost of round-trip postage.*

IMPROVING RELATIONS

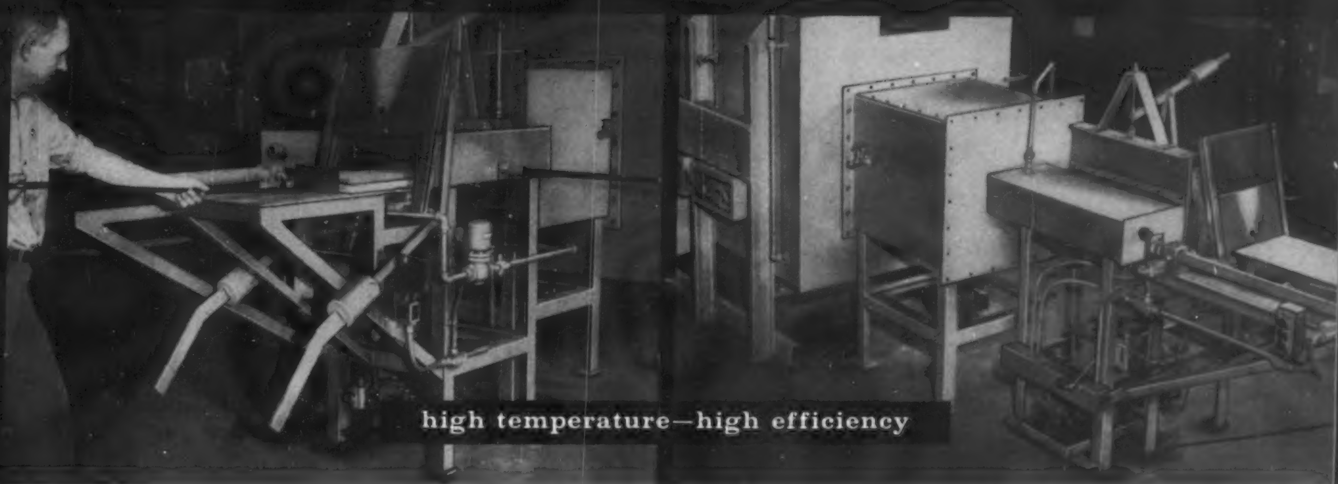
Thank you very much for your kindness in arranging to send MODERN CASTINGS to the National Foundry Craft Training Centre for at least one year. These journals will be read by between 100-200 apprentices each year and should do much to stimulate interest in AFS among the next generation of foundrymen. I think that AFS and the Institute of British Foundrymen will grow even closer together in the years to come.

G. R. SHOTTON
Shotton Brothers Ltd.
Oldbury, England
President, Institute
of British Foundrymen

COOPERATIVE PLAN

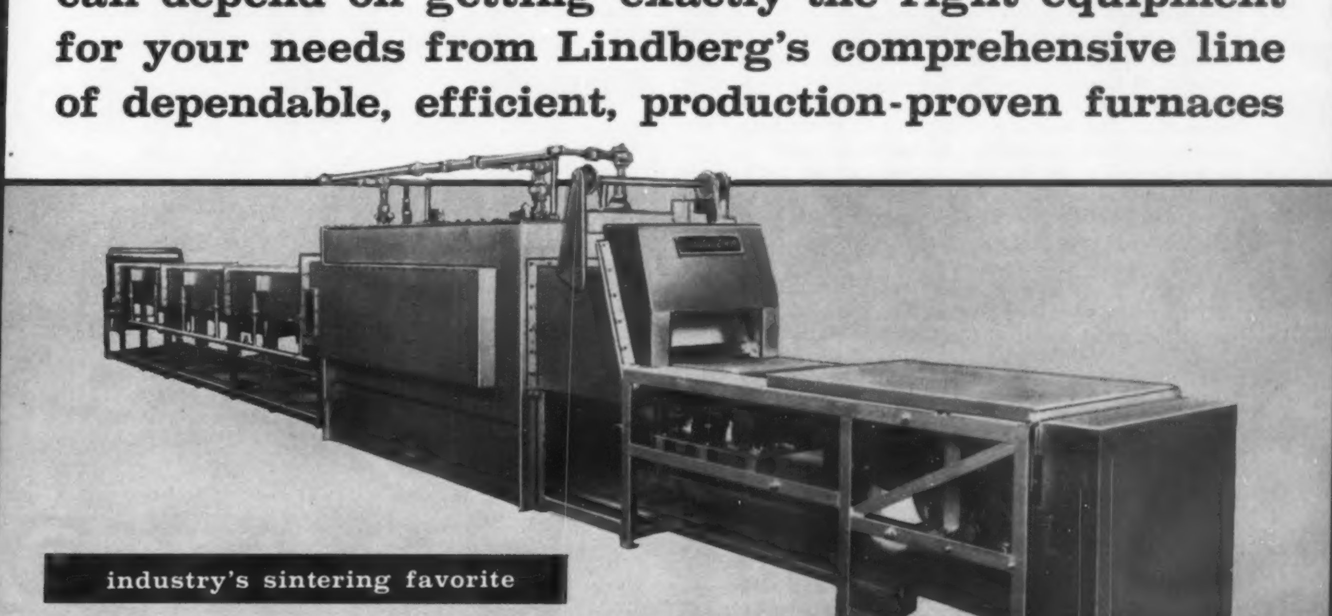
We are very pleased with the article "Cooperative Training Program Gets Student Approval" on page 134 in the February MODERN CASTINGS.

JEAN M. DOCK
Dock Foundry Co.
Three Rivers, Mich.

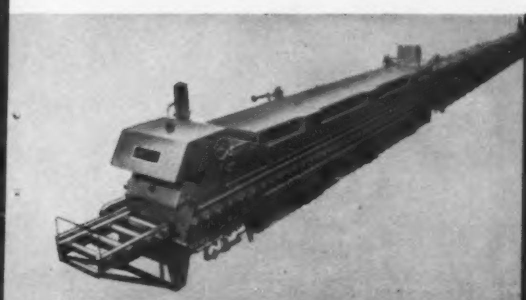


This new Lindberg Molybdenum Element Pusher Type Atmosphere Furnace has a maximum temperature of 3000°F. with 60KW input. It embodies high temperature refractories suitable for low dew point without muffle and is ideal for sintering stainless steel compacts in hydrogen or dissociated ammonia. Furnace provides side loading and discharge ports with purging chambers. Installation at right also shows conveniently located ammonia dissociator and control panels.

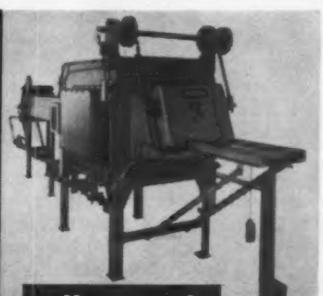
If your production processes require sintering you can depend on getting exactly the right equipment for your needs from Lindberg's comprehensive line of dependable, efficient, production-proven furnaces



This Lindberg Mesh Belt Continuous Type Furnace has a temperature range of 1300°F. to 2100°F. and production capacity up to 500 lbs. per hour. It is a very popular type furnace for sintering small metal powder parts. Similar furnaces are also being used for brazing and bright annealing.



Lindberg Roller Hearth Continuous Type Furnace handles loads up to 2200 lbs. per hour in temperature range 1300°F. to 2100°F., for bright annealing, silver brazing and sintering metal powder.



Lindberg Hand Pusher Batch Type Furnace has a temperature range of 1300°F. to 2500°F. Also sintering capacities from 25 to 300 lbs. per hour available.

For full information on the furnaces illustrated and Lindberg's complete line of sintering and brazing furnaces, just get in touch with your local Lindberg Field Representative (see classified phone book) or write direct. Please remember, too, that Lindberg offers a variety of Atmosphere Generators to provide, efficiently and economically, the proper atmospheres recommended for use with our sintering furnaces. Heat Treating Furnace Division, Lindberg Engineering Company, 2440 West Hubbard Street, Chicago 12, Illinois.

Los Angeles plant: 11937 S. Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg Ltd., Toronto.

LINDBERG
heat for industry

Worker Attitude Has Changed Safety

by H. F. DIETRICH

We have come a long way on the road to industrial safety since the days of one-eyed molders. Sometimes the road was rough and rugged. The greatest advance was made with the changing attitude of the workers themselves toward their own safety.

It is difficult to understand why men believe that stupidity is a sign of courage, but it has been so through the ages, and it is still true. The gladiator of Caesar's time faced hungry lions without quaking—at least outwardly. That was stupid. Except for the pressure of public opinion, he would have run for the nearest exit.

The knight of the round table went out to fight dragons. As long as he confined his adventures to this sport, he was playing it smart and safe. Dragons were hard to find. His greatest discomfort was the difficulty he experienced in trying to dislodge the vermin under his tin safety suit. By the time he got back home, where he could find a can opener and get undressed, the size of the parasites increased in his imagination until he could tell tall stories about fire breathing dragons. After being boxed up in the same tin can with thousands of beasties, he probably believed the stories himself.

No doubt there was a written guarantee with each piece of dragon fighting safety equipment. But when the knight put it on and rode against a charger and heavy lance to test it that was stupid. A suit of armor might very well resist dragon's breath—especially when there were no dragons—but it might leak when hit with a lance half the size of a phone pole. Safety equipment should be used for the purpose for which it was designed.

Perhaps we can all agree that the actions of gladiators and knights were idiotic and too far in the past to generalize from them to modern man. But, today we still have neoidiots playing Russian roulette, teenage drag pilots playing "chicken," and morons driving lift trucks at high speeds—all to prove their courage.

For those of us who were responsible for the introduction of safety equipment in the foundry, these mores were hard to overcome. Just as the ethics of the oldtime gunslinger required that he show no fear, and that he allow the other man to draw first, so the old time molder was required by contemporary opinion to show a calloused disregard for safety in his work. He poured without goggles and lifted copes that might better have been handled with a crane. The objective wasn't to save time, but to prove to his fellow workers that he didn't fear metal, and that he was a "Poor-Man's" Hercules. Until he had one eye and a permanently bent back, the molder couldn't brag about his prowess.

The first safety equipment didn't do much to help the cause of those interested in accident prevention. The small, round goggles pressed on facial nerves until wearing them became torture. The closed cups certainly were not designed by anyone who had ever handled hot metal. A molder who had just finished ramming a floor would find himself blinded by fogged lenses when he tried to pour. He was really safer without them. As a result, where wearing goggles was mandatory, we had the best protected foreheads in the world.

The first hard-toed safety shoes could have been used in the inquisition. They bent at just the right spot to cut off the tops of the worker's toes. After wearing them for a week the man was a hospital case.

Through education we have made the worker conscious of *his* safety. No longer is safety equipment uncomfortable as the knight's armor, for safety equipment manufacturers have engineered comfort—and style—into today's modern safety goggles, glasses, shoes, gloves, and clothing.

Obviously, to be effective safety equipment must be used. No matter how hard a manufacturer tries, he can't build into any safety device a protection against stupidity.

Tonawanda Electric Steel Casting Corp.
uses Baroid's

NATIONAL*
Western Bentonite

FOR
CENTRIFUGAL
PUMP CASTINGS

TONAWANDA ELECTRIC STEEL CASTING CORPORATION uses NATIONAL Western Bentonite as the sand-bonding agent for a wide variety of steel castings. The 930-pound and 325-pound centrifugal pump castings illustrated here were cast in molds made from sands containing NATIONAL Western at TONAWANDA's North Tonawanda, New York, foundry.

Baroid's NATIONAL Western Bentonite helps produce close tolerance, fine-finish castings of all metals—steel, malleable iron, gray iron, brass, aluminum or magnesium.

For good molding, better cores and high-refractory core wash formations, use NATIONAL Western. NATIONAL cores dry faster, have higher dry strength and contain less gas.

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Circle No. 140, Pages 129-130

Leaded Steel—
Does It Cause Lead Posioning?

by Herbert J. Weber

Lead poisoning has occurred in all types of industries and human activities, but in the foundry industry it originally was found only in non-ferrous shops. Non-ferrous foundrymen long ago learned how to prevent it. Now, with the advent of leaded steel, perhaps ferrous foundrymen can profit by their experience.

The production of leaded steel castings is a fairly recent development in this industry and offers the advantages of better machine finish and increased machine-tool life.

It is made by the steel industry where the practice is to pour steel into ingot molds while lead shot is added to the metal stream. The amount of lead retained in the steel is about 0.35 per cent.

In the early days, cases of lead poisoning occurred among men inoculating the steel and among those flame-cutting the ingot.

A recent case of lead poisoning was reported in one plant machining bar stock made from leaded-steel ingot. This case is of doubtful validity since tests showed that the concentration of lead in the blood, urine and atmosphere was safe. The diagnosis was based solely on the presence of porphyrins in the urine. This is a non-specific test for lead poisoning since there are other causes of porphyrinuria.

In foundry practice, lead is added to the ladle in the form of lead shot or litharge (PbO); 0.15-0.20 per cent lead being retained. The melting point of lead is 620 F and that of litharge 1630 F.

There is evidence to show that lead is dissolved in the steel rather than suspended in it. It would seem then—according to the electrochemical series—that in using litharge, the oxygen atom unites with an iron atom leaving elemental lead in solution.

If this is so, it would be less hazardous to use litharge rather than lead shot because of the great difference in melting points.

The maximal allowable concentration of lead in air is 0.2 milligrams per cubic meter of air. This is an extremely low concentration which, if greatly exceeded, would produce cases of lead poisoning.

In one foundry, the concentration of lead reached 200 milligrams per cubic meter of air during inoculation with lead shot. This demonstrates that the inoculating operation requires local exhaust ventilation or other preventive method if lead poisoning is to be avoided.

In welding or grinding leaded steel, there is a potential lead hazard even though the amount of lead in the steel is very low.

The percentage of toxic material in a parent substance is no gage of degree of hazard. For example, consider a wall composed of 95 per cent stone and 5 per cent mortar. When a workman demolishes the wall, the amount of dust produced will be almost entirely mortar dust—a fact that bears no relationship to the percentage composition of the wall.

In welding leaded steel, lead fume will be released because of its high vapor pressure. In grinding, fine lead dust will be given off, thus the upper limit of safe atmospheric concentration may be exceeded.

Where cutting of leaded steel castings with tools creates chips or turnings, or when castings are annealed, there is no lead hazard.

The mere presence of lead in the blood and urine is not of itself a basis for a diagnosis of lead poisoning. All of us—even infants—have some lead in the blood and urine. Thirty to 50 micrograms for 100 grams of whole blood and 150 micrograms per liter of urine are considered normal.

When this "normal" value is exceeded it indicates that there has been some lead absorption. It does not necessarily mean that lead poisoning (intoxication) has occurred.

The manufacture of leaded steel castings involves some hazard, but the hazard is easily controlled as it is in non-ferrous foundries, by local exhaust ventilation or by use of respirators when exposure is sporadic.

Communications . . . An Industrial Headache

By R. E. Betterley

The "Importance of Communications" and the "Means of Communications" were discussed in the February and March issues, respectively. Let us now consider information pertaining to plant communications.

Effective plant communications are vital to successful plant operation. Although generally accepted, this fact is sometimes underestimated and misunderstood. It has often been said that in reality nothing could ever happen within a company unless preceded by communication—of one form or another. The backbone of any organization is the people carrying out its activities. And the guidance of people is only as efficient as the communications conveying the desired actions and results.

Communications within an organization can be classified several ways. They may be *formal* or *informal*, *one-way*, *two-way*, or *multi-way*. They may be considered also in terms of direction: *vertical*, *horizontal*.

Vertical communications usually exist in a formal manner from management down through the echelon of key personnel. They are usually written memos, directives or bulletins pointing out policy or action to be taken. Management should carefully weigh these communiques before releasing them. Too often such communications are one-way only, dictatorial in nature and achieve only partial cooperation and forced obedience. History has proven the weaknesses of autocratic control.

These strong forces distort information and are detrimental to "listening" when given orally. Ideally, *vertical* communications should, as much as possible, be set up to be *two way* —making it possible for key personnel to report and give suggestions back to management.

In two-way communication, management and supervisors energetically seek the ideas of their subordinates. This provides opportunity for the free transfer of valuable information. *One-way* communications only can seriously reduce the creativity of employees. Creativity, in turn, builds better communications because it provides incentive and a "why" for communications.

Obviously some vertical information is passed informally by top management, and rightly so. This can develop into a loose policy where communication may fall into the category of someone "spilling the beans." Communication of this type usually originates well up the management ladder. Too often it is premature and incomplete. And when passed on to a "trusted" friend it can soon become detrimental *horizontal communication* within the plant.

Horizontal communications are usually informal and exist across levels of plant personnel such as departments, areas, etc., or between employees of equal rank in different departments. This is the "grapevine," the "rumors,"—"scuttlebutt," whatever you want to call it. This is *dangerous* communication because it is so *effective* in "getting through" and most generally conveys *inaccurate* or *incomplete* information.

Management should be aware of the dangers involved in this type of communication and improve the plant's *vertical* communications. When information is given, it should be *complete* and *accurate*.

Multi-way communication is becoming increasingly popular in plant operation. It employs a group effort in the form of conferences, staff meetings, departmental head meetings, etc. It utilizes the advisory benefits of group thinking. This is effective, *providing top management has an open mind and is willing to actually consider suggestions.*

Plant communication is the backbone of a company's success. All methods of plant communications should be considered. Advantages and disadvantages should be weighed for specific application. However, in recent years, management has favored the more democratic two-way and multi-way methods

Next Month—
How to Communicate

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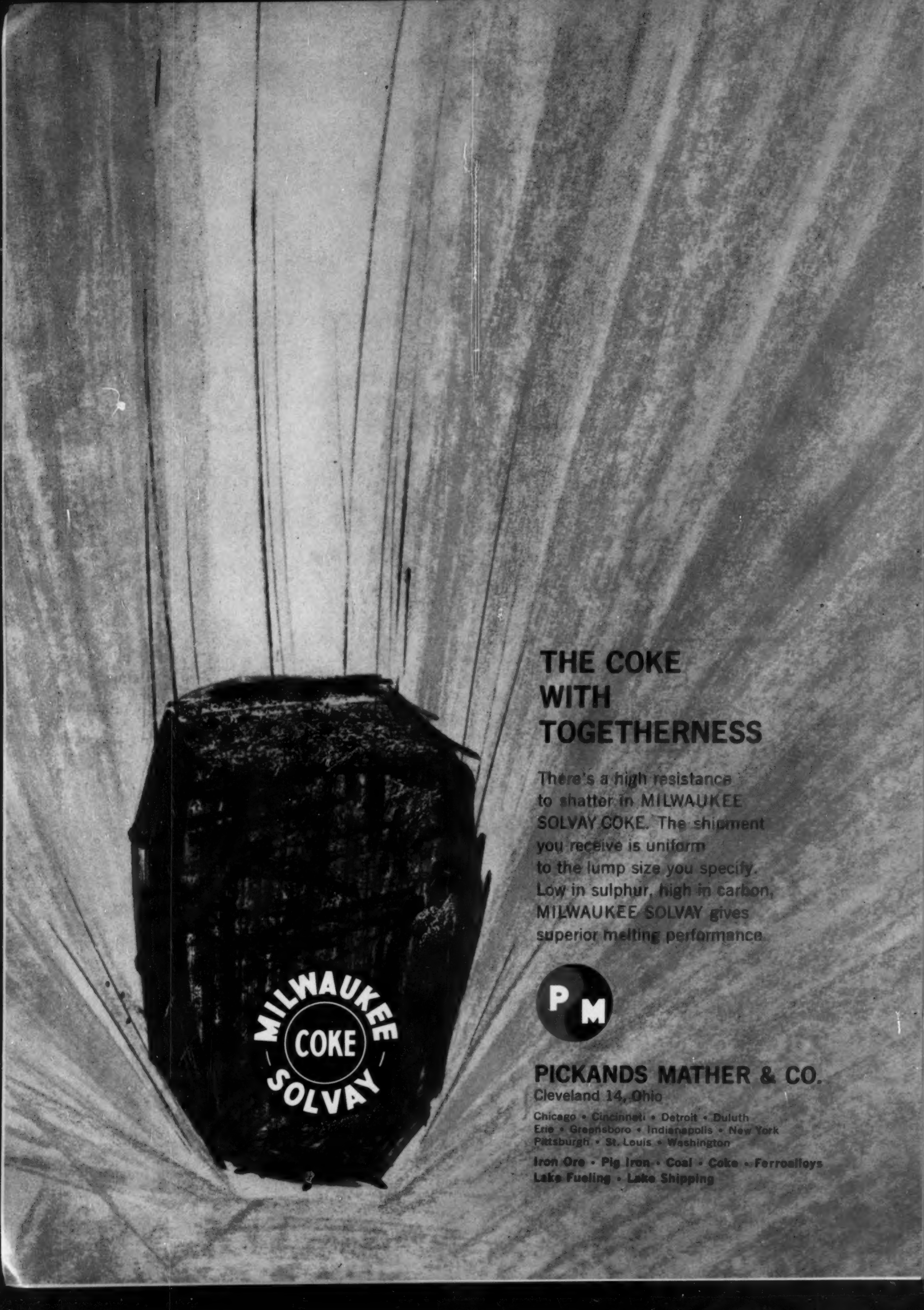

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Metalcasters can meet the rigid demands of aerospace industries today and win a larger share of other industrial markets tomorrow . . . if

1. *They apply new technology to bring castings up to standards forced by fantastic environmental extremes (See the special report below by Editor Jack Schaum).*

2. *They anticipate the needs of other industries seeking parts which are much stronger, lighter and more reliable (See John Varga's report on page 38).*

3. *They are willing to expend research and production efforts that American Brake Shoe Company put out to develop high strength castings that are 100 per cent reliable (See "Casting High Integrity Steel" on page 40).*

Aerospace Industries Demand Integrity in Every Casting

INTEGRITY—in casting after casting after casting! That is the unanimous demand of all the engineers reporting in MODERN CASTINGS recent survey of the Aerospace Industries.

Today and the next 10 years will witness greater emphasis on reliability and simplicity with less concern for direct weight reduction. Designers prefer the simplicity of achieving complex configurations in metalcastings but . . . the "forty-'leven" tests that must be used to prove casting reliability are driving manufacturers to the ultimate extreme of extravagance.

Absolutely nowhere in our industrial complex is there an area with structural needs approaching those of the aerospace industries. Here are just a few of the environmental extremes that aircraft and spacecraft are exposed:

1. Re-entry speeds into earth's atmosphere of 10,000 miles per hour and temperatures of 5000 F.
2. Liquid hydrogen at -423 F.
3. Hydrogen—oxygen fuel systems burning at 5000 F.
4. Pressure as low as 1.5×10^{-6} mm Hg.
5. Accelerations ranging from 10 to 250 G's.
6. Speeds of Mach 4.
7. Dangerous levels of electromagnetic radiation, high energy particle radiation, and dissociated or ionized gas zones.
8. Bombardment by spatial debris traveling 45 miles per second.

These are but a few of the forces that aerospace vehicles must withstand to be operational. Small wonder that this industry is push-

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A Special Report

by JACK H. SCHAUM

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ing the technological capabilities of every material and method of fabrication to meet their needs. Designers are years ahead of the manufacturers who are struggling desperately to close the time-gap between "experimental" and "operational".

The fact that some foundries today are meeting the rigid specifications proves that aerospace requirements are possible to achieve.

Here is a direct quotation from a recent report of the Aerospace Industries Association: "Generally the use of castings will reduce and in many applications weldments will be used in place of them. In high strength, high temperature applications relatively small forgings will be assembled into larger, complex, built-up components since it is not indicated that the cost and time to produce very large forgings will be acceptable. Aluminum and magnesium alloys will still be the basic materials for subsonic vehicles and, for advanced types, will continue to be used for internal structures due to environmental requirements."

In an address before the Aircraft Castings Association, A. H. Langenheim, Project Engineer, Air Material Command, stated:

"When we watch the construction of a modern airframe, we see what extraordinary efforts have been made to refine and perpetuate the mechanical assembly of small bits and pieces. The builder feels that he can inspect each part as it is formed from sheet, bar, or forging. Then, being sure of its quality, he joins it to another 'perfect' part and inspects the joint appropriately. This process continues until the airframe builder delivers a completed machine, theoretically with no weak spot.

"He can't do this with a casting. He turns to a casting only when a part is too intricate to fabricate or practically impossible to forge or machine, and so he gets a cast shape. Nearly always he doesn't like it; it isn't smooth enough—it isn't of exact size—he isn't sure that the test coupon is representative. He suspects invisible cracks, and his magnetic tests may give him some proof.

"He suspects interior unsoundness, shrinks, cracks, porosity, or segregation, and his x-ray or ultrasonic machines can always turn up some 'indications'. He questions whether the casting is good enough, but he must take no chances, and so the casting goes back to the vendor, who growls about the unnecessarily high and impossible requirements set up by current specifications."

Castings Are Used

In spite of this purgatory of tests that every casting must undergo to prove its integrity, metalcastings have managed to carve out a substantial share of the fabricating market. This casting market for aircraft and missiles is divided amony four basic groups—engine castings, ground support—equipment castings, primary airframe castings, and miscellaneous castings. Here's how certain companies are using castings in aircraft and space craft:

Missile Division, Chrysler Corp. —Many castings are used in the Redstone and Jupiter missile systems. Aluminum alloy pressure castings are subjected to 100 per cent radiographic inspection. These valve bodies and housings combine maximum reliability with minimum weight in propulsion systems operating in contact with liquid oxygen, concentrated hydrogen peroxide, alcohol, kerosene, and high pressure gases. Structural applications are use within the airframe as blockers and stiffeners. Aluminum 195 blockers serve in hoisting the missile. Stiffeners used in connecting tail section to booster section are A Z 91 C magnesium castings.

Another group of flight castings include such items as antenna housings, frames for openings in skin sections, support frames for guidance equipment, covers, caps, etc. These parts are made predominantly from aluminum alloy 356, Almag 35, and Magnesium AX91C. Ground support equipment built by Chrysler uses about 100 individual castings in direct missile applications such as pump bodies, impellers, valve housings, mobile equipment, trucks, launcher parts, and electrical boxes. Alloys include aluminum, bronze, nodular iron, and steel.

Chance Vought Corp.—magnesium pylons for supporting sidewinder missile on F8U-2N Crusader, 60 pounds each, alloy AZ-91-T6.

Northrop Corp., Norair Division

—pulley brackets; cable and rod quadrants; fuel fittings; access doors; linkage; canopy frames; windshield components; housings; gyro yoke and gimbals; electronic module cases; seat arms, buckets, braces, and air duct leading edge lips—65 per cent of these are cast magnesium and the rest are aluminum. Also canopy support brackets and canopy hinge arms made in high strength aluminum per MIL-C-21180. Over forty 17-4 PH alloy steel investment cast aileron hinges, canopy lock housings, brackets and hooks are used in the supersonic T-38 Talon Trainer.

Grumman Aircraft Engineering Corp.—cast non-ferrous landing wheels, control columns, control bellcranks; steel pylons and arresting hook toes.

Boeing Airplane Co.—aluminum 356, magnesium AZ 91 and 347, 410, and 17-4 PH steels used in casting brackets, supports, hydraulic and air fittings, equipment enclosures, gear cases, valves, door assemblies, grills, levers, steering wheels, handles, etc.

Goodyear Aircraft Corp.—from large steel structural castings for foundation and structure of radar units to small investment castings for guidance equipment in the nose of a missile. Use aluminum alloys 356, A356, 355, Almag 35, and 40E; magnesium alloys AZ 63, AZ 91, AZ 92, and ZK 51; and Class 1, 4B1, 4C2, and 4C4 steels.

North American Aviation, Inc.—hydraulic valve bodies and structural fittings cast in 6 A1-4V titanium and the following steels—355 CRES, 13-8 CRES, H-11, Rene 41, PH 15-7 Mo CrES.

Thiokol Chemical Corp.—aluminum and magnesium cast turbopump housings, precision cast super alloy buckets and vanes and aluminum housings and aluminum and stainless valve assembly parts.

General Electric Co.—cast front frames, compressor castings, gear boxes, nozzle diaphragm partitions and turbine buckets as complete structures; cast strut ends to connect between inner and outer diffuser passage; investment cast variable vane trunnions and instrumentation bosses are welded to sheet metal air foils and shins. Cast alloys run the gamut from magnesium to low temperature components in forward part of engine to AISI 410, AISI 347 and A 286 for intermediate temperatures and high temperature nickel base alloys in turbine and afterburner sections.

The Martin Co.—electronic ground supports are using many aluminum castings including a complete console the size of a desk.

Air Material Command—aluminum and magnesium: Brackets, levers, access doors and frames, control panels, landing gear wheels, wing reinforcements, piston engine crank cases, and other secondary structures. Steel: Jet engine rotors and stators, engine mounts, turbine blades, engine track fittings, armament pylons, rudder actuators, launching frames, turbine nozzles, vertical-spindle fuselage frames, and other primary structures. Super Alloys: Compressor blades, turbine buckets, rocket nozzles, and similar "hot" engine parts.

To be more specific, consider the Talos Missile, a surface to air, supersonic, ramjet-propelled guided missile. It uses 15 magnesium module castings to house electronic components, plus cast magnesium antenna housings, and innerbody fairing and aft cone.

One of the interesting castings on Norair's supersonic T-38 Talon Trainer is the aft canopy support. This aluminum alloy 356 casting meets minimum requirements of Ftu 38,000 psi, Fty 28,000 psi, and four per cent elongation—and replaces two forgings and various fittings. The canopy torque arm on the same plane was formerly a 17-7 PH steel weldment. A high strength aluminum casting has replaced the steel weldment at a savings of $300 per plane.

Save Parts and Money

Some 20 steel castings are used in the Regulus II missile launcher, replacing 73 detail parts in the experimental design and eliminating 300 hardware items such as nuts and bolts.

In the April issue of Modern Castings, page 40, be sure to read the article telling how American Brake Shoe Co. is casting high-integrity steel castings to meet aerospace demands for 300,000 psi tensile strength.

Richard L. Albrecht, sums up the status of castings applications in these words: "In currently operating aircraft, castings comprise about 14 per cent of the net airframe weight. In future aircraft and aerospace vehicles this will probably drop to seven or eight per cent. While this may appear to be a very small amount, it is extremely important to the mission of the vehicles."

Although we more often hear what's wrong with metalcastings it is encouraging to learn that aerospace engineers recognize and endorse many of their inherent advantages. No other process converts molten metal directly into the desired shape without regard for complexity or size.

Often the design configuration is so complex that the only way to produce the shape is by casting. This bears out the old adage, that if it can be drawn on a drafting board it can be cast. Even when complex shapes can be produced by machining the cost is often prohibitive in comparison with casting. Coring out of intricate passageways leads to weight reduction and elimination of machining.

Castings Preferred

Castings are preferred on prototype work because they permit wide parameters of flexibility in design.

In general, cast structures are the most economical design for a complicated shape. Although raw materials costs may be higher, tooling and machining costs are considerably lower.

Saving parasitic weight in space vehicles is particularly critical when you realize that every pound saved in the final stage of a multistage missile may save as much as 1000 pounds of fuel in first stage!

R. E. Patsfall points out this casting advantage peculiar to turbojet builders: "High temperature super alloys are much stronger in creep and stress rupture at elevated temperatures when cast than when used in wrought form."

The ability to cast inside surfaces of waveguide components to a 63 RMS finish makes castings a preferred method for fabricating feed horns, E and H bends, transitions, and mixers.

One designer points out that the aerodynamic requirements of aircraft dictate thinner wing sections with more pointed leading edges, and propulsion and control require-

ments leave practically no space for structural fittings in the fuselage. This results in fittings of extreme complexity which require maximum strength. They are not suited to forging and are costly to machine. This statement very ably presents the reasons why castings are attractive to aircraft makers.

Northrop Norair uses so many castings because: (1) the requirement for weight control makes mandatory an almost 100 per cent machining of forgings to remove excess weight; (2) castings offer freedom in configuration and complexity achieved by no other fabrication method; (3) cast structure evenly redistributes applied loads in contrast to directional grain and load conductance of wrought material; and (4) economy is an important factor.

In the February issue of MODERN CASTINGS, S. A. McCarthy, Senior Production Design Engineer, McDonnell Aircraft Corp., presents the tenet that "every steel casting design undertaken for aircraft or missile application forms a challenge or compromise." The challenge comes in obtaining tolerance ranges in the as-cast condition leading to elimination of costly machining operations. The compromise involves design modifications to help foundrymen make a better casting.

Castings Make the Market

Whether the use of metalcastings grows or shrinks is a fate very much in the hands of the foundry industry. A few years ago an all-out effort was summoned to make the aerospace industry aware of the advantages of castings. They took a close look at the casting process, revised their design thinking, and gave our foundry industry a chance to show off its ability. Unfortunately too many of the foundries fell flat on their faces. Acceptable sample castings were carefully prepared in order to get the orders. But when it came to delivering quantities, the scrap rate approached 100 per cent. Buyers went through, and for that matter are still going through, a tedious period of weeding out the unreliable suppliers.

And this is why RELIABILITY has become the number one deterrent to the use of metalcastings.

Aerospace vehicle components must have guaranteed quality. But to guarantee casting quality, much time and money must be spent on testing. Buyers are not content to judge a casting on the merits of a test bar. So every casting must run a gauntlet of non-destructive tests which include x-ray, sonic, and magnetic particle inspection. This adds so much to the cost that some space vehicle builders find it cheaper to hog-out the shape from uniform quality wrought stock. Advanced machine tools with tape controls are making this approach even more competitive.

Many New Demands

Inability to discover microshrinkage in some castings points to a need for more exacting inspection devices and improved foundry techniques to insure sound metal throughout all castings. Test work is needed to calibrate mechanical property loss as a function of radiographic indications of internal discontinuities.

More cast metal parts would be used if significant improvement could be shown in:

1. Lowering pattern costs.
2. Producing thinner walled castings.
3. Mechanical properties.
4. Accuracy and precision of configuration.
5. Tolerance and surface finish.
6. Melt quality.
7. Inspection criteria.
8. Heat treatment.
9. Performance ability.
10. Reliability of delivery.
11. Alloy capabilities.
12. Design parameters.

New alloys are needed with high strength—weight—temperature ratio so new designs can penetrate the thermal "thicket".

Higher levels of foundry capabilities are needed to help produce the advanced weapons concepts that the industry foresees in the next 10 years. Only by creating and applying new metalcasting technology can we support our share of the new aerospace technologies. Foundrymen must prove their ability to transfer new techniques from the laboratory into the production line. Tomorrow's job cannot be done with yesterday's tools.

Although the tonnages involved in today's aerospace markets may seem puny in comparision with automotive purchases, one point must not be overlooked. Just as soon as progressive foundrymen demonstrate their ability to make reliable high integrity castings, the big-tonnage, more mundane industries, are going to revise their designs to make better products demanding similar high quality castings.

Aerospace Industries . . . Stepping Stone to New Castings Markets

By JOHN VARGA, JR.
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EVER INCREASING CRITICAL REQUIREMENTS in the aerospace program make improvement of materials and processing techniques mandatory in today's technology. Higher strengths combined with minimum weight make high strength steels very desirable as structural materials.

However, the higher the strength level of steels, the more difficult and costly the fabricating and machining operations become. Costs also increase.

Cast parts offer the aerospace designer a process whereby he can utilize more complex designs, achieve the desired strength properties, and still reduce the cost of producing the vehicle. These advantages can be achieved only with castings that are produced under the strictest quality control procedures combined with the best

casting technology and design capability.

Aerospace vehicles require parts made as perfect as humanly possible. Contrary to the belief of many foundrymen, this requirement for perfection is not centered on castings alone. Other fabrication techniques are under the same pressures for improved quality and greater reliability. The requirements for more consistent mechanical properties in sheet steels has resulted in the use of vacuum treatment techniques and consumable electrode melting to attain the desired results. While these processes may in some instances produce steels with improved mechanical properties, more important, they produce steels that are more consistent in their properties.

These processes are not adaptable to the average foundry using the more conventional molding techniques. But, there is one part of the vacuum melting and consumable electrode melting techniques that the foundryman can use to advantage—that is the use of the best melting materials available. The metal quality required for high strength castings can be achieved only through the use of high quality charge materials. This has been shown to be true for aluminum, and magnesium, as well as steel.

Know Your Capabilities

A foundryman that is to be considered as a supplier for aerospace castings, must know the capability of his own particular process. He must know what his process is not capable of doing as well as what he can do with his process. Such knowledge must be based on a sound technical background as well as experience. Foundry technology is at a stage of development today such that the numerous trial and error procedures used in the past to determine correct gating and risering, should be eliminated or at least reduced to a minimum.

In the past years, aerospace designers have specified that castings be 100 per cent sound. This specification resulted from two shortcomings: (1) the lack of proper radiographic reference standards; and (2) the lack of sufficient good design data for cast metals. The first item represents a lack of cognizance within the aerospace industry and the casting industry as to up-to-date requirements for inspection standards. This shortcoming is to be remedied soon.

The second item, however, is the responsibility of the foundry industry itself. If the foundry industry is to achieve its place as a supplier of top quality parts at reasonable cost, the necessary design information must be made available to the designers, be they aerospace designers, automotive parts producers, or appliance manufacturers. The great majority of designers are trained by experience and education in the design properties of wrought metals. As a result they place a greater reliance on wrought metal properties.

You Must Sell Design

How many foundrymen have even bothered to determine how their cast products measure up to their competitors. Selling design is a powerful tool that the foundryman has overlooked too often in the past.

Foundrymen may consider the capital expenditure necessary for radiographic equipment too expensive for their particular operation, yet such equipment can be used to increase the yields of casting by determining how much metal in the riser is performing no useful function but adding to the cost. Gray iron foundries, who are in as competitive situation as can be found in the casting industry, have utilized radiographic techniques to improve their casting yield.

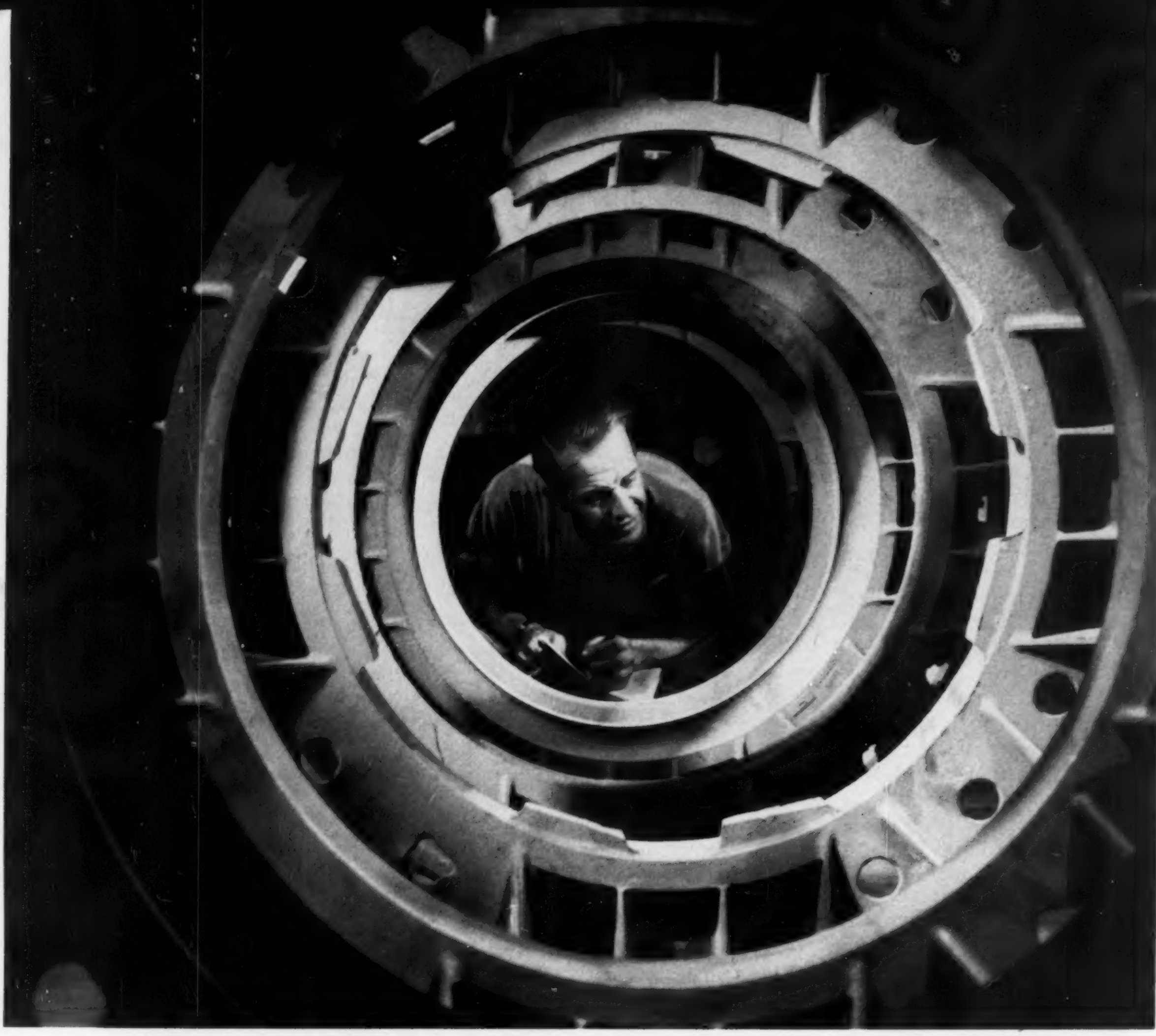
While this discussion so far has been concerned with castings for the aerospace industries, the requirements for the other defense industries are taking similar approaches. Equipment for the Army must be lighter and stronger. Why? Much of the material for the foot soldier must be airborne; the soldier himself is being given more fire-power which means he ends up carrying more equipment; and the soldier is often airborne in interests of greater mobility. All these requirements place a greater importance on lighter weight and greater strength. Similar requirements for the Navy are a must also. The problem of weight in Naval vessels is indicated very dramatically by recent articles describing an experimental submarine that is to have a hull made of aluminum instead of steel.

The majority of foundrymen have been treating the requirements specified by the aerospace industries as though pertinent to that industry alone, and that in time it will pass. Actually this is not the case. Requirements for lighter, stronger and more reliable parts are being specified by other industries. The foundryman who is unwilling to make the attempt to meet the requirements for the aerospace industry today, will find himself losing other markets to other processes tomorrow. The gray iron industry is already receiving strong competition from aluminum engine blocks on a weight basis.

Weight limitations are already in existance in the trucking industry where a pound saved in the truck or trailer means an additional pound of cargo carried. Many machine tool parts that originally were made as castings are today being made as weldments. This inroad into a castings market was made because of weight and design. Design studies were made to determine how to improve the dampening properties of a welded structure, a property that is inherent in gray iron. Developments in high-strength structural steels have made it possible to construct lighter buildings and bridges.

Sound Technology Required

The design philosophies of lighter weight and higher strength that originated in the aerospace industry has already made itself evident in today's industrial technology. Mobile equipment that is lighter for a given strength level than its predecessor, requires less power to move, and makes more power available for doing work. The design requirements specified by the aerospace industry should be accepted by the foundry industry as a stepping stone toward improved products. The foundry of the future is going to be one that is based on sound basic technology and good quality control, as well as sound management. More foundries today should be in the position of one foundryman who feels that he can produce a better product at less cost than a forging, and compete with products fabricated from sheet materials.



Missile airframe components can be made of high integrity cast steel, but they must pass stringent inspections to be acceptable. Flaws permissible in normal castings would cause rejection.

Casting High Integrity Steel

American Brake Shoe Company is commercially producing castings that are:

- *Stronger than ever achieved before*
- *100 per cent reliable*
- *Perfectly uniform and homogenous throughout*
- *Producible in any size and shape*
- *Dimensionally precise*
- *Lighter per unit strength*
- *Less costly than parts made by other methods*

Which means they are successfully competing in the aerospace market right now!

DEVELOPMENT OF HIGH INTEGRITY STEEL CASTINGS—uniformly stronger than ever before achieved commercially—has opened new fields to the casting industry.

Previously, castings could not be used for critical applications where complete uniformity, reliability, and strength were essential. Although castings were theoretically strong enough, such faults as inclusions, "hot tears," and minute unsound spots brought strength levels down below customer requirements.

This closed, for the most part, the field of aircraft and missile components to castings because of the great weight needed to achieve sufficient strength in conventional castings.

At American Brake Shoe Co., the high integrity process eliminates the faults and produces uniform tensile strengths—as high as 300,000 pounds per square inch. The process makes it possible for designers of highly stressed parts to take advantage of the plus features of casting in competition with other fabrication methods.

Today the company is successfully producing missile launching gears, jet engine gear case covers, air craft pylons and other components. The process was brought to its present stage of high development by the production of a series of missile base rings, the main structural component of the third stage of a still classified missile.

The advantages of casting over other fabrication methods include: (1) ability to produce virtually any shape to nearly its finished size, thus reducing machining; (2) ability to produce parts of any size, from a few pounds to hundreds or even thousands of pounds; (3) production of parts in one piece, without the complication and doubtful reliability of welded or riveted joints; and (4) low cost, as compared with other methods of making comparable parts.

A Wide Range of Shapes

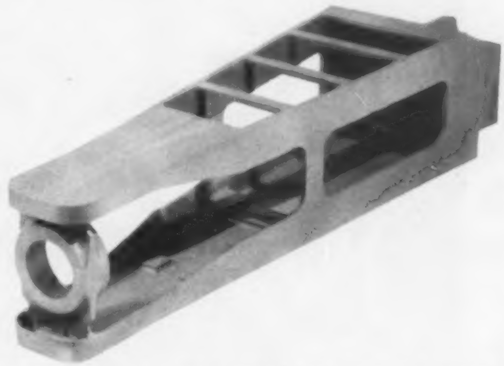
High integrity castings can be made in a wide range of metals, sizes, and shapes, with an equally wide range of properties. This means they should be competitive wherever uniformity, reliability and high strength are primary considerations. They should compare favorably with parts made by forging and machining, fabrication by welding, or by machining from solid.

Forging, as an example, produces high strengths, but is very expensive for low volume production. There is a practical limit to the shapes that can be achieved, and if subsequent machining is necessary to produce the finished shape, casting will often prove more economical. There is also a practical limit to the size of part that can be forged, while high integrity casting has virtually no such limit.

Fabrication by welding is usually used for shapes that cannot be forged. This process requires expensive jigs, and, more often than not, results in parts with a great number of welded joints, limiting reliability. Distortion is always a problem with welded assemblies, and complex heat treatment is usually necessary.

Machining from solid does produce parts of excel-

Missile launching cradle is alloy 4330 steel. It is 48 inches long and weighs 155 lbs.



Spar fin is cast alloy 8740 steel. It is 32 inches in length and weighs 60 lbs.

This armament stores pylon is alloy 4330 steel. It is 27 inches long and weighs 65 lbs.

Missile airframe component of alloy 8740 steel is 36 inches in diameter and weighs 312 lbs.

Cores are carefully set in specially prepared ceramic molds, important step in the process of casting high integrity steel requires attention to detail.

The mold is carefully blown clean prior to the final step of setting the cope on the drag.

lent strength and reliability, but it can be extremely costly for any complex shape.

High integrity casting, on the other hand, can produce almost any desired properties by the selection of the steel to be used. It can produce a part in virtually any size, and, when required, can be made to high standards of dimensional accuracy.

Tensile Strength to 300,000 psi

To provide strength, stainless steels, air hardening steels, and other alloy steels can be cast by this method. Depending upon the steel chosen, ultimate tensile strengths will range from 150,000 to 300,000 psi, with a similarly broad range of yield strengths and related properties. When required—as in some missile components—tensile strengths of 260,000 psi can be guaranteed throughout the casting, with actual values running above 280,000 psi!

Where extreme strength is not as important a requirement as uniformity of properties, the tensile strengths will range from 150,000 to 250,000 psi. (As a comparison, previously 150,000 has been considered high strength for conventional steel castings with 200,000 psi rarely achieved.)

Virtually any size is possible in high integrity casting, but there probably will not be much demand

Back-pouring a center riser is the finishing touch in pouring a missile ring. In the initial step, two ladles are used, 12,000 lbs. of metal are poured, and the entire operation takes only seven seconds.

for multi-ton castings. Such large castings are usually made massive to provide stability, weight, and vibration absorption, and their sheer bulk usually provides adequate strength. High integrity castings are needed where high strength with light weight is a critical factor.

It is completely possible, when required, to produce high integrity castings with excellent standards of dimensional accuracy. In the aircraft and missile castings produced by this method, only light finish machining is needed, and that only on low-tolerance surfaces. The "as cast" surface is so good that it requires no machining in many applications.

Combination of Materials and Methods

The high integrity process is a combination of proprietary materials and methods with extreme care and control at every stage. There is no magic step that produces these properties, and even a minor slip at any step in the process will degrade the properties below required levels.

Basically, the production of high integrity castings requires a high level of "know-how" in selecting raw materials and alloying ingredients; in selecting and producing molding materials to control size, finish, and casting characteristics; in the precise controlling of melting and pouring temperatures and conditions; in controlling cooling rate; and finally in inspecting of the finished casting.

Most steel castings are made primarily from scrap steel, which costs two to three cents a pound. Metallurgy is controlled rather loosely. In contrast, high integrity castings begin with Swedish sponge iron (at 17 cents a pound) or electrolytic iron (costing 35 cents a pound). Metallurgy is controlled within hundredths of a percentage point for critical alloying ingredients.

The molds and cores used in the process are made of proprietary ceramic mixtures developed to produce controlled shrinkage rates in the casting as it cools, good surface finish, and close dimensional tolerance and stability. The molds are made with a large number of risers and are designed so that the poured metal will reach and fill every area of the mold within seconds—before the metal has a chance to cool and fail to fill the mold.

Single or double ladle pouring is used to insure proper filling of a complex mold. Pouring temperature is controlled within a few degrees to achieve the best metallurgical properties and prompt mold filling. Although it takes a week to prepare the mold for a complex missile part—and a few hours to bring

X-ray, isotope radiography and magnetic particle testing are a few of the inspection processes high integrity castings must undergo before acceptance.

Technicians carefully check each high strength steel airframe component to make certain it meets customer specifications prior to radiographic inspection.

the metal up to correct temperature—the actual pouring from twin ladles takes only seven seconds. If it took a few seconds longer, the mold would not fill properly.

Because of the way the mold is made, and to insure complete integrity in the casting, the actual yield is often as low as 25 per cent in the process. For example, a 360-lb. missile casting requires the pouring of about 1,200 pounds of metal. The excess goes into gates, risers, etc., which are subsequently cut off. However, this excess metal is not a complete loss. Since it is of known metallurgy, it is used as part of the charge for the next casting.

Three-stage Treatment Used

When ultra high-strength castings are required, a three-stage heat treatment cycle is used. This includes homogenization, austenitizing, and tempering. Heat and time are precisely controlled. One of the most important accomplishments of American Brake Shoe metallurgists is that they can run complex parts through this three-stage cycle without casting distortion or change in critical dimensions.

Because these castings must be free of defects that might be acceptable in conventional castings, they are individually inspected by X-ray, isotope radiography, and magnetic particle testing.

All of these factors lead, of course, to higher costs as compared to conventional casting. But, high integrity castings do not compete with conventional castings. They compete with forged, welded or machined components, and are often less expensive in the long run.

This entire process had its birth when American Brake Shoe metallurgists set about the rather prosaic job of designing a two-part tooth for the dippers of power shovels. The tip, which does the actual digging, is made of manganese steel which work-hardens under impact and provides excellent wearing qualities. But the base part of the tooth (the part which attaches to the dipper or bucket), could not be made of manganese steel because manganese deforms somewhat under impact.

The base had to be strong, uniform, and had to resist deformation under multi-ton impact so that new tips would fit properly when replaced.

The result of research on this requirement was a form of high integrity steel casting—rough in shape, but extremely strong and solid. These two-part dipper teeth are now a staple item of Brake Shoe's American Manganese Steel Division.

With this first glimmering of the bright future for the high integrity process, Brake Shoe metallurgists obtained a research and development contract from the U. S. Air Force for the development of a process for casting airframe components.

Work on this contract continued through 1958, and resulted in the process which is now used to produce missile and aircraft components for several major producers.

Accurate Time from a Cast Sun Dial

Whenever the sun shines on the Norton Co. you can check your watch for accuracy against a cast statuary bronze sun dial. The device will give standard and daylight time—from sunrise to sunset on a clear day.

SUN DIAL READINGS ACCURATE to within one minute are made on bright days at Norton Co., Worcester, Mass. A cast statuary bronze sun dial, presented to Norton on its 75th birthday by its across-the-street neighbor, Heald Machine Co., does the job.

New England ingenuity has made the readings as accurate as many wound watches. Technically, it is a rotating sun dial developed by a New England businessman-inventor, the late Maj. Victor E. Edwards, West Boylston, Mass. It was cast by Hill Bronze Alloys Co. of Worcester.

Patterns and detailed notes were loaned to Heald Machine Co. by Major Edwards' daughter, Mrs. Vernon E. Kilgour. Machine work and calibration was performed by Heald.

Two features contribute to its unusual accuracy. One is its exact calibration, and the other is its ability to be moved to catch the sunlight. Readings can be obtained without complicated equations.

Sun dial terminology appears as technical as the foundryman's vocabulary. To obtain the correct time, the gnomon, or gooseneck, is turned to a position which pinpoints sunlight to the correct reading on the analemma or figure-eight shaped date reading on the gnomon.

When the sun spot is correctly placed, both standard and daylight saving time may be read directly opposite two pointers.

To obtain the correct time, turn the goosneck about its axis, A, until the tiny spot of sunlight shining through pinhole B falls squarely on the line of the figure-eight shaped marking adjacent to the current month, C. The time is read directly opposite the hands at D.

Clay Test Proves New Control Tool

New technology is providing better quality castings at lower cost for green sand foundries. Nearly 300 metalcasters are taking advantage of a simple test for effective clay content, and the results are described as "spectacular."

TODAY, ALMOST 300 foundries are applying a rapid test for effective clay content and putting it to work making better castings and less scrap.

When first reported in the March 1960 issue of MODERN CASTINGS, as "Molding Sand Control by Green Compressive and Shear Strength Testing," by R. H. Heine, E. H. King, and J. S. Schumacher, the test for controlling green sand quality was immediately recognized as a technology-for-profit breakthrough.

The original article describes a method for quickly and accurately determining the bonding power of clay in foundry sands.

Two basic charts—on the opposite page—were designed to relate green compressive strength and green shear strength to "effective clay" content. The term effective clay measures the true bonding power of the clay, as opposed to the conventional AFS clay content which includes ineffective burned and dehydrated clay.

A great deal of the successful competitive come-back made by green sand foundrymen in the past several years can be attributed to better sand control. Now foundrymen have a new control tool which lets them maintain a constant known percentage of effective clay in the sand. As a result numerous casting defects can be avoided and better quality castings produced at lower cost—the ultimate goal of every foundryman.

The benefits accruing to the foundries reporting their experiences to MODERN CASTINGS are close to spectacular. Six of these foundries report here how they have profited by adapting this new technology to their operations.

Cut scrap 50 per cent

National Cash Register's foundry has cut scrap 50 per cent! But their biggest gains have come from improved casting finish and dimensional accuracy with savings from reduced grinding and machining. With greater sand uniformity, mold production is also higher.

Frank Foundries Corp. report scrap defects attributable to swells, cuts, washes, inclusions, and drops never exceed 1/2 per cent. Use of the chart has also improved their dimensional accuracy and casting finish. Another savings comes from ability to hold sand additives to a bare minimum.

Ohio Malleable Division of The Dayton Malleable Iron Co. now gets a more favorable sand that results in harder more compact molds. This in turn accounts for meeting closer tolerances and achieving better finish. They now have fewer drops and stickers so more molds can be produced.

Since Inter-State Foundry Co. started using this control chart several months ago they have noted casting finish gradually improving to a smoother and more saleable casting. Scrap has been reduced slightly and savings are expected to show up in the cleaning room.

Texas Foundries, Inc., consider the effective clay chart to be their most valuable single control tool! Reduced sand inclusions, erosion defects, drops, and pinholes have meant a lower scrap rate. Of almost equal importance is the improved workability of the sand. This has led to higher mold production, cleaner partings, and fewer soft rams.

Lufkin Foundry & Machine Co. uses the test to avoid under bonding which causes drop outs and over bonding which leads to clay balls, additional ramming and loss of material. It also frees the sand technician to run other tests.

Each foundry must construct its own master control charts to suit

the sand system used. The optimum operating zones will naturally depend on the metal and the size of castings being produced.

H. E. Grable at Ohio Malleable Division of The Dayton Malleable Iron Co. approached the problem this way: "We took our molding sand and mixed it with different amounts and types of clays, in a 50 pound sample, and made castings with the different experimental batches. From our casting results we determined the amount of clay and additives we should use in each 1800 pounds of system sand we produce. From then on we controlled the sand to obtain the same results by adding or reducing the amount of clay and additives in the sand, keeping the moisture as near constant as possible. By adding the green shear test to our normal test, we were more able to use this chart. Also, from observed casting results we shaded off an area in the chart and hold in that range. Before making any changes we evaluate them in experimental 50-pound batches.

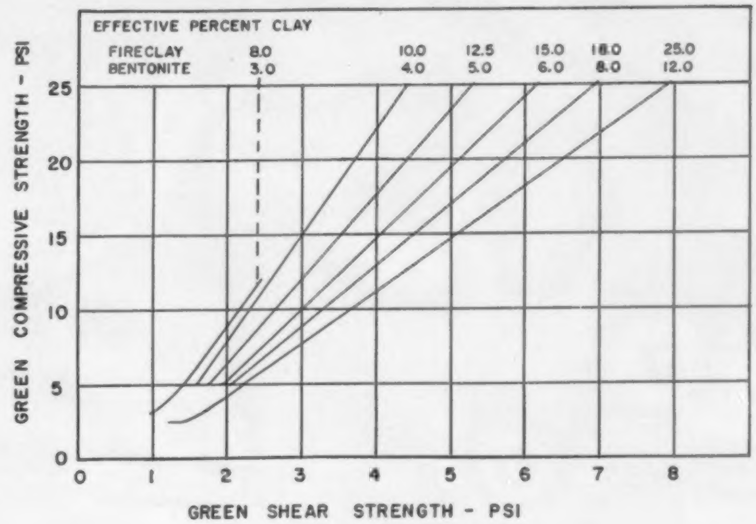
Helps temper control

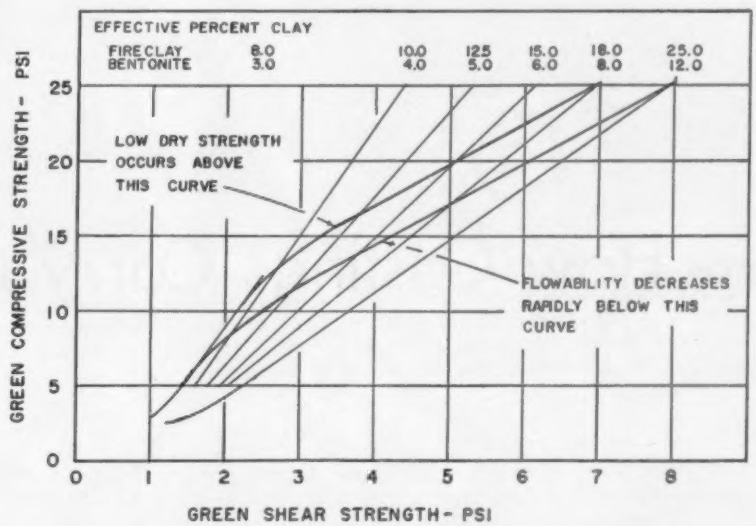
Jack Woltz, Sand Foreman at Texas Foundries, has found it possible to extend the usefulness of the chart even further. He uses it to indicate the degree of temper in the molding sand. It takes only a few minutes as compared with previous practice which was always a few days to a week behind. Being able to determine the proper moisture for temper control immediately has improved their ability to consistently maintain a smooth casting surface.

Most of the foundries using the effective clay chart now find it unnecessary to bother with the less meaningful AFS clay determination. As Frank Martin puts it, "Effective clay is that part which does the bonding work, not what can be floated out by water and weighed on a balance."

The ease of maintaining a continuous quality control vigil with the Effective Clay Chart leads to new high standards of uniformity so essential to producing consistent castings in green sand molds—another demonstration of the new foundry technology being turned into profit.

How To Construct An Effective Clay Chart





Top chart is constructed by determining green compressive and green shear strengths on mixes comprised of all new ingredients and mixed to bring out maximum green strengths. The values for any one mix are used to determine a point on the chart. A line is drawn from the point to the proper per cent of bentonite (western or southern) or fireclay used in the mix. Since all ingredients are new, this line represents effective clay. Other lines are drawn by testing representative mixes using different binder contents.

Samples of sand from the foundry system are then tested. The values for compressive and shear strength determine a point on the chart. A line is extrapolated parallel to the master line and its intersection at top line will indicate effective clay content. If the value falls below the desired control, new clay is added. If above, dilute with bond-free sand.

The lower chart is a refinement that establishes maximum and minimum control limits for foundry sands so as to yield the best quality castings. These limits are usually a function of moisture content. As moisture decreases, green strengths increase and vice versa.

If sand properties fall above the top limit line, sand is too dry and defects such as dirty castings, expansion defects, over-rammed or cracked molds occur. If properties fall below lower limit line, sand is too wet and you have problems with stickiness, flowability, rough finish and gas defects.

Cast gray iron grab hooks carry sacks of mail on this overhead "power and free" conveyor system at "Project Turnkey," the Post Office Department's experimental facility at Providence, R. I.

How Castings Carry the Mail

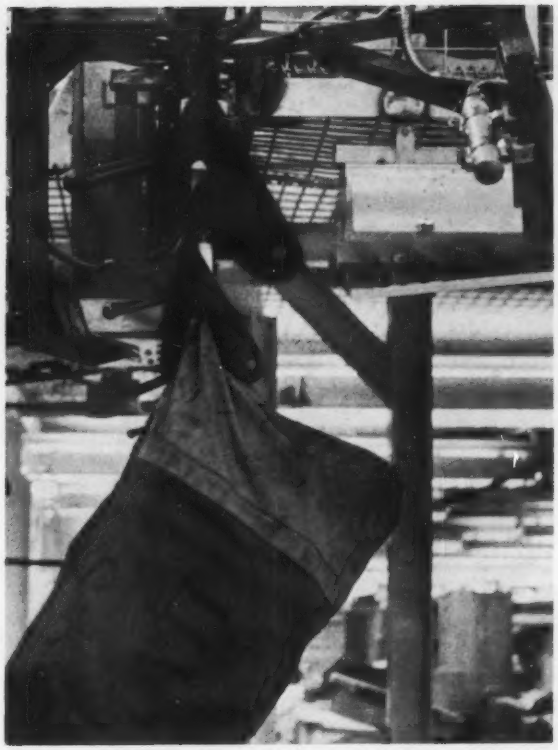
Faced with a deluge of 62 billion pieces of mail annually, Uncle Sam turned to automation in the post office. "Project Turnkey," a new facility in Providence, R. I., is the proving ground for materials handling equipment designed to speed up the flow of mail. Gray iron, malleable, and aluminum castings play an important role in the systems and could spell a new market for metalcasters.

UNIQUE METHODS OF MAIL HANDLING at "Project Turnkey," the nation's first fully automated post office, have created a new market for the metalcasting industry.

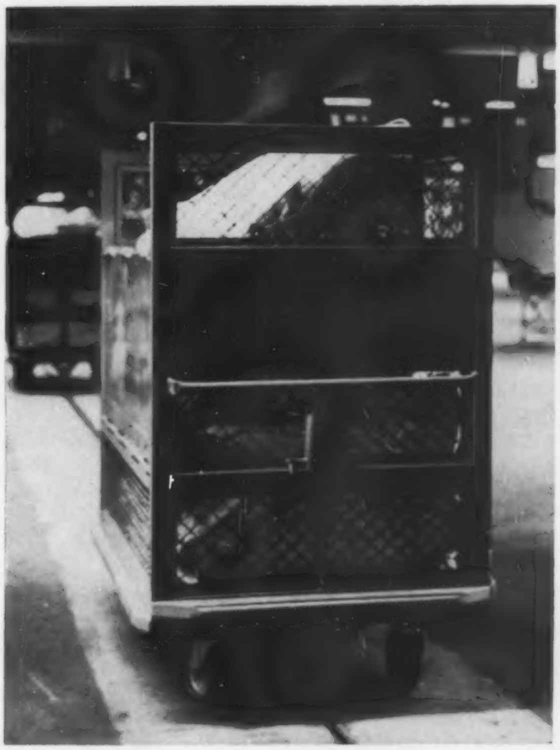
Completed this year in Providence, R. I., by Intelex Systems, Inc., subsidiary of International Telephone and Telegraph Corp., "Turnkey" is both a working reality and a valuable laboratory for testing electronic and mechanical devices.

Automation is the only hope of the Post Office Department in its race against the growing use of mail. In 1960 an avalanche of 62 billion letters and packages literally inundated the 36,000 post offices in this country.

The major problem is to keep mail flowing in and out of the post offices at high speed. To solve the problem at "Turnkey," five key operations were put into effect. These include a continuous conveyor system for moving mail from one place to another, automatic separation (culling) of the different kinds of mail, automatic facing and cancellation of letters, semi-automatic sorting of letters to various destinations (machines can handle over 18,000 letters per hour), and a fully mechanized parcel sorting system



The grab hooks on an automatic dispatching overhead conveyor can be tripped open at a specific point by the unlatching device pictured at the top right of this photograph. A magnetized code card, passing a reader mechanism, actuates the drop switch.



These "Towveyor" carts move without human assistance along a 1708-foot system of drive chains located beneath the floor. They carry sacked parcel post packages from the docks to the parcel sorting machines and return to the docks with processed mail.

making use of conveyor belts and pallet conveyors.

Castings play their role in the 15,728-foot system of overhead and ground-level conveyor units which have been installed by Jervis B. Webb Co. These conveyors carry letters and packages from one destination to another without human assistance.

A "Towveyor" system of mail carts run on tracks guided by a continuous chain drive beneath the floor. They carry packages to and from the shipping platforms at speeds of 80 feet per minute along 1700 feet of track.

Cast malleable iron pusher dogs and idler assemblies control the truck travel. The cast dogs push against the tow pins moving the carts along specified paths. Idler assemblies guide the drive chain of the tow line on its track. There are 125 pusher dog units and 500 idler assemblies being used at "Turnkey."

A completely new feature is an automatic dispatching overhead conveyor which carries outgoing mail from the sacking area to chutes where the sacks are loaded onto outgoing carts. Pre-magnetized code cards are mounted behind grab hooks which hold the sacks enroute. When the coded card passes a matching reader mechanism, it actuates an air-powered drop switch which trips the grab hook latch and drops the sack at the right station. The grab hooks on the conveyor are made of gray cast iron.

Identical castings are used on a similar system, a "power and free" conveyor in the dock area. Here cast spring pusher dogs move mail sacks to specified areas for the culling operation. They move on a drive chain under "power" or "free" by gravity or hand.

Still another conveyor system, a tray conveyor, carries parcel post packages to pre-determined stations and dumps them. Tray latches and tripper housings are made of cast aluminum on these units.

The new market for castings is evidenced by the fact that Post Office officials foresee the need for similar systems in every major post office in the very near future. There is already a predicted load of 140 billion pieces of mail annually by 1985.

Although "Turnkey" has come in for some recent criticism because of the electronic equipment, plans are still going ahead to construct a second unit, "Project Gateway," at Oakland, Calif. Fifteen post offices already use some of the new equipment and authorization has been made for a dozen more installations in the near future.

Melting Practice for Aluminum Die and Permanent Mold Casting

An exclusive Modern Castings *presentation of the official AFS-sponsored exchange paper before the Institute of Australian Foundrymen, New South Wales Division at their annual meeting in Sydney, Australia.*

By Donald L. Colwell, Vice-President
Apex Smelting Co.
Cleveland

When properly handled, aluminium is very easy to cast in any form. However, several important precautions must be observed or serious trouble can develop.

Both die casting and permanent molding depend upon repeated rapid casting operations under uniform conditions. If these conditions vary, difficulties will develop leading either to a non-uniform product or to a high rate of rejection. Variables must be controlled and maintained uniformly. This applies to the metal and its handling as well as to mechanical variables in the casting process.

Uniformity of the gating and venting system in the die casting process and gating and risering systems in the permanent mold process are easily maintained as they are machined into the die and cannot vary during a run. Variations in die and mold temperature, pressure, cycle control, and the like will not be discussed here. It's assumed that they are maintained uniformly. This discussion is limited to the aluminum alloy variables.

When trouble develops in any casting operation, it's always easiest to blame the metal used since improperly smelted ingot could conceivably be the cause. The ingot metal variable will be discussed first, and later attention will be given to melting and handling of the aluminum alloy. The latter can often cause more trouble by introducing irregularities arising from faulty handling of molten aluminum rather than in the ingot.

The first and most evident variable is composition. Table 1 lists popular alloys used, both in the die casting and permanent mold processes, as specified by the American Society of Testing Materials. The basic composition for die casting is 3½ per cent copper, 9 per cent silicon, and balance aluminum. Two basic aluminum alloys for permanent mold casting—6 per cent silicon plus 4 per cent copper and 7 per cent silicon plus 0.3 per cent magnesium—are widely used.

The table indicates that many of the limits are so wide that a whole series of alloys can be included, all of which are within specification limits. A good metal supplier will study his customer's needs and supply ingot metal to him within very much narrower limits in order to maintain the uniformity the customer requires.

The needs are not necessarily the same for all customers. A wide awake customer should consult with his supplier and insist on limits as narrow as practicable to maintain a uniform composition.

With modern control by the direct reading spectrograph, limits of plus or minus one per cent on the major elements indicated are not necessary. The wider the limits the wider the possible variation between two lots of ingot and the more likely the user will run into trouble in making the castings. The alloy composition, therefore, should be closely controlled.

Within a given composition, however, there are other reasons for an ingot causing trouble. Non-metallic inclusions, such as oxides, nitrides, carbides, cell feed, and gases, can be harmful, both in the casting operation and in subsequent machining operations. Many times included intermetallic compounds are responsible. All of these may be found in the ingot as supplied, but good clean ingot is more often contaminated in the subsequent melting operations. These inclusions will be discussed in greater detail later. But, first it is wise to set forth some of the char-

acteristics of molten aluminum which are basically responsible for the inclusions. A more thorough understanding of aluminum characteristics can often point out a remedy to the alert foundryman.

Chemical Activity

The first characteristic is chemical activity. Aluminum is easily oxidized in the solid state and rapidly in the molten state. This oxide forms a skin, and very often advantage can be taken of this skin to prevent further oxidation. The oxidation of molten aluminum, when exposed to air, is so rapid that undue agitation presenting fresh metal surfaces to the air causes a very rapid increase in the amount of oxide formed.

The work of the American Foundrymen's Society on gating has emphasized the fact that a stream of molten aluminum, unduly agitated, can cause a surface foam very much like that on the top of a freshly poured glass of beer, or on an agitated detergent solution in a washing machine. When this froth gets into the casting all kinds of troubles can develop—such as poor surface, leakers, hard spots, streaks and the like.

Molten aluminum also reacts readily with water vapor. Water in any form introduced into molten aluminum is immediately dissociated into its hydrogen and oxygen, both in the nascent condition. The oxygen immediately oxidizes the aluminum and the hydrogen gas goes into solution. The solubility of hydrogen in aluminum is high at high temperatures but drops very rapidly at the usual pressure casting temperatures. The H_2O can come simply from an atmosphere of high humidity, from products of combustion in contact with the metal, from improperly dried furnaces or crucibles, or from damp ingot. If ingot has been stored outside, the hydrated aluminum oxide coating is very difficult to dry before immersion in the molten aluminum, and hydrogen pick-up is almost a certainty.

Figure 1—Aluminum and aluminum-iron alloy formed inside iron pot. Center plate is aluminum-iron-silicon complex; iron-rich alloy at right. 200X

Table 1—Popular DC and PM Alloys

Process	Alloy	Cu	Si	Mg	Fe	Mn	Zn
Die Casting	ASTM SC84A	3.0-4.0	7.5-9.5	0.10	1.3	0.50	3.00
Permanent Mold	ASTM SC64D	3.5-4.5	5.5-7.0	0.10	1.0	0.50	1.00
Permanent Mold	ASTM SG70A	0.25	6.5-7.5	0.20-0.40	0.6	0.35	0.35

(Where single units are shown, these indicate maximum amount permitted)

Aluminum is almost a universal solvent for other metals, especially at high temperatures. Iron crucibles, iron tools, and the like are quickly dissolved in aluminum, increasing the iron content. Copper, nickel, chromium, zinc, cadmium and other heavy metals can be picked up from inserts or plated parts carelessly charged into the melting pot, further changing the composition of the bath.

Serious Attack

The attack of aluminum on iron pots can be very serious at the usual permanent mold casting temperature of about 1400F, but at the usual die casting temperature of about 1200F this attack is much less. A section showing the alloying of aluminum and iron in an iron pot is shown in Figure 1. Iron crucibles operating at either temperature should be given a refractory coating of clay, lime or similar refractory with a binder of sodium silicate.

It is best to lightly spray this coating onto the crucible when it is hot. Be sure to thoroughly scrape down the crucible sides after the metal is removed and before the spray is applied. Refractory crucibles do not require an inside coating. They are more fragile, and, due to their lower heat conductivity, have a slower melting rate and hotter working conditions. Both types of crucibles have a tendency to collect oxide at the metal line and should be kept clean.

Reverberatory furnaces are most commonly used for breakdown to supply hot metal to groups of holding furnaces at the machines. If proper precautions are taken against oxidation and undue agitation, the reverberatory furnace is an efficient melting unit. Large furnaces can be operated continuously at temperatures somewhat higher than required in the holding furnaces. Either cold metal, scrap, or both can be charged. Small holding furnaces can be operated in the same manner for a 1400F pouring temperature, provided the bath is large enough to avoid undue chilling when cold metal is charged. At the 1200F melting temperature, however, they should be charged with liquid metal.

Reverberatory furnaces require

the same attention to cleanliness as do crucible furnaces. Aluminum oxide, when freshly formed, is soft and amorphous. When it collects on the hot walls in an open hearth furnace and is subjected to the heat of the burners, it quickly transforms into an abrasive crystalline form which is detrimental to a casting.

Any agitation which would cause the metal to splash on the hot refractory is harmful because this metal quickly oxidizes, bakes, and forms the same hard aluminum oxide. This type of alumina when crystalline is used as a commercial abrasive. The amount of metal oxidized is also higher than with a crucible furnace, consequently metal losses are higher.

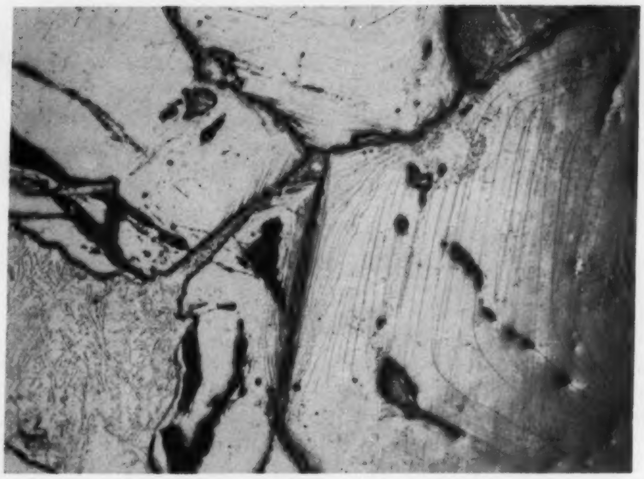


Figure 2—Showing section sludge. Note that it settles in layers. 40X

Minimum Agitation

Whatever type of furnace used and whatever type of casting made, it is important that agitation of molten aluminum be kept to a minimum. Rapid oxidation of the metal makes it impossible to expose fresh molten metal surfaces to the atmosphere without an increase in the amount of oxide that is formed. This is worse when the temperature is higher. When a molten aluminum bath or a molten aluminum stream lies quietly, the oxide skin protects it from further oxidation; but when the bath is agitated or when the stream is broken oxide pick-up is rapid.

When a thin stream of aluminum drops from a ladle one foot or more above the metal surface, it causes a foaming action on the surface of the holding bath due to the breaking of the skin from agitation. The result is an increased amount of aluminum oxide. Automatic ladling drops aluminum into the well of a die casting machine with a minimum of agitation and consequently a minimum of foam. A newly developed pump for handling aluminum has an air-driven motor which drives a rotor at the bottom of a pot. This forces metal up through a refractory tube where it is dropped into a launder from a height of about two inches, thereby minimizing the agitation.

Studies by the American Foundrymen's Society made at Battelle Memorial Institute on vertical gating have made specific recommendations for gating systems designed to secure a quiet flow of metal throughout the sprue, runner, gate, and even as metal rises in the mold. The recommended sprue design in the vertical system minimizes agitation and aspiration of air into the sprue as the metal drops. Here are positive recommendations for vertical gating:

1. Rectangular sprue, tapered with small end at bottom.
2. A cylindrical enlargement of the runner at the base of the sprue.
3. A runner with a cross-sectional area equal to twice the cross-sectional area at the base of the sprue.
4. An extension of the runner past the gate to provide a trap for the first liquid to enter the gating system.
5. A gate flared with its exit end larger to reduce velocity of the metal stream.
6. A side riser to prevent turbulent metal from entering the mold directly from the gate. The side riser also helps in feeding shrinkage.
7. A web connection between the side riser and the mold cavity to introduce the metal quietly and progressively from bottom to top.

One big advantage of a new low pressure casting process developed in England and Germany, and now introduced into the United States, is that molds are mounted directly over the crucible or pot. Metal is allowed to rise into the mold under low air pressure without agitation so that the mold is filled quietly from below. Both E. C. Lewis and D. J. Flynn have described the process before the AFS.

Porosity in castings may be due to improper flow of metal so that air is trapped. These cases are usually gross and very easily remedied. When caused by gases in the metal, the sources of those gases must be identified and eliminated in order to secure sound castings.

L. W. Eastwood emphasizes the importance of dissolved gases in aluminum, and points out that hydrogen, usually from water vapor, is the worst offender. Since solubility of hydrogen in aluminum increases rapidly with temperature, dissolved hydrogen is much more of a factor in the permanent mold process than in the die casting process. It is especially necessary that aluminum for permanent mold castings be protected from sources of moisture vapor.

Moisture Sources

Common sources of moisture are wet or cold ingot, corroded ingot, products of combustion in contact with aluminum, moisture released from oily or dirty scrap, or even moisture in the atmosphere on a damp humid day. Fortunately, degassing is relatively easy and is often practiced where sound pressure type castings are desired.

E. Scheuer points out that many times a certain amount of gas in solution in a permanent mold casting is desirable in order to counteract severe effects of shrinkage. He suggests a method for adding hydrogen under controlled conditions. In extreme cases, such as in the production of agitators for washing machines, the metal is often deliberately over-gassed to obtain a smooth surface on the casting. In this type of casting internal porosity is not objectionable.

In the die casting process, dissolved hydrogen is not as great a factor. If aluminum is allowed to stand at 1175F or 1200F (the usual casting temperature) most hydrogen will come out of solution, since at these temperatures the solubility of hydrogen in aluminum is very low. Consequently, even with gassy metal, the gas comes out of solution and rises to the surface when held at these temperatures.

The usual source of porosity and gases in die castings is the lubricant added to the die and shot well. If the plunger and die casting die could be operated entirely without lubrication, the density of the castings produced would be greatly improved. Since this is impossible, keep the amount of lubrication to an absolute minimum and use a vehicle which is easily volatilized by the hot die before it has a chance to become entrapped by entering metal. If a heavier vehicle is used, and particularly if used in excess, it doesn't have a chance to leave the die and is trapped in the metal. A porous casting when sectioned and allowed to stand overnight will often collect drops of oil on the cut surface, as such lubricant is released from the pores of the casting.

Use of the vacuum die casting process is growing. Under vacuum a portion of the lubricant is drawn out before metal enters the die. In the vacuum process it is even more important to use a vehicle which volatilizes easily, as the vacuum does not get a chance to pull out any heavier lubricant which does not volatilize until hit by the stream of molten aluminum.

It is usually not necessary to use much flux when melting good clean ingot. Practically speaking a charge usually contains a certain amount of dirty scrap. Fluxes help remove this dirt and oxides formed by improper metal handling. Solid fluxes are composed mainly of chloride and fluoride mixtures which reduce surface tension of the droplets of metal.

Probably the best all-around flux from the standpoint of clean aluminum is gaseous chlorine. Other gases such as nitrogen and argon may also be used to bubble through the aluminum and mechanically remove oxides and gases. Chlorine has an additional action in that there is a certain amount of chemical reaction which aids further in the separation. Chlorine has the disadvantage of being toxic and corrosive to surrounding structures. It is sometimes mixed with nitrogen so the chemical action of the chlorine and the mechanical action of the nitrogen are combined. Any excess chlorine which escapes to the atmosphere is diluted.

Gaseous fluxes should be introduced at the bottom of a bath through a perforated tube and allowed to bubble very slowly so that the surface of the bath is hardly broken. After chlorinating several minutes the bath is allowed to stand for 10 or 20 minutes more to give foreign matter a chance to come to the surface before it is skimmed.

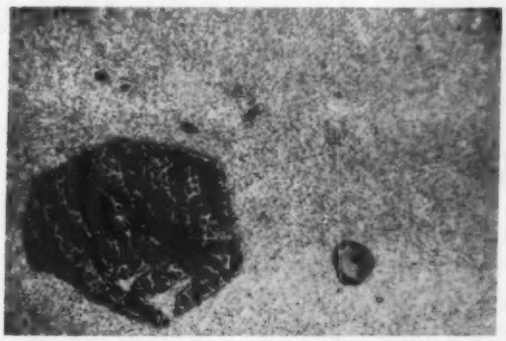


Figure 3—A piece of hard complex trapped in a die casting. 40X

Preparing the Bath

In preparing an aluminum bath, it is best to melt about 50 per cent of the charge as ingot metal and flux with a solid chloride flux at about 1300F. Scrap can then be added and the fluxing operation repeated at about the same temperature. If degassing is necessary, it can be done at 1250F or 1275F and the metal allowed to stand.

For die casting, you may charge directly into the holding furnace and for permanent mold casting, heat to the proper pouring temperature without undue agitation. If a viscous scum forms on the surface during the casting operation, it should be cut with a chloride type flux and skimmed. The slushy nature of the surface of the bath should be broken down and nothing remain but a dry powdery layer which is easily separated and skimmed off.

Aluminum fluxes are hygroscopic. If they are not thoroughly dry, moisture may be introduced into a bath and gas added instead of removed. So keep all aluminum fluxes thoroughly dry.

When aluminum is alloyed with copper and silicon, as is common for the pressure process, alloying elements are put into solution at temperatures of 1400F to 1500F. When a thorough alloying job is done, various constituents of the complex alloy are in a condition close to equilibrium, particularly if much of the metal has been previously alloyed and remelted. At casting temperatures of 1200F or below many of these elements are easily precipitated. Often an accumulation of heavy metallics forms at the bottom of the aluminum bath.

Sludge accumulates when solid

ingot is charged into the molten alloy at about 1200F. Metal immediately freezes around the ingot. This metal and the ingot then slowly melt away. During this process, the temperature range is wide and the number of temperatures infinite, consequently all high melting point compounds are freed at some time during the cycle and settle to the bottom as a sludge.

Preheating the ingot to 400F or 500F would have little effect on the phenomenon. Even if preheated to 1000F the latent heat of aluminum would extract enough Btu's from the molten bath to cause the same result. Sludging is prevented only if molten aluminum is charged into a holding furnace at the highest possible temperature (without raising the casting temperature of the bath beyond reasonable limits).

A section of sludge at 40 diameters is shown in Figure 2. When a lump of such sludge is entrapped in a casting, it causes hard spots as shown in Figure 3. These inclusions can quickly ruin a machining tool, the large ones nick the cutting edge and those of microscopic size rapidly dull the tool. Analyses of such samples show an iron content of 3 to 8 per cent, a manganese content of 1 to 3 per cent, a silicon content from 10 to 20 per cent, and often chromium to the extent of 1 per cent or more. Analyses of a bath from which sludge has formed shows depletion of these elements.

Recommendations

Here are some general recommendations on the handling of aluminum for die casting. If these recommendations are followed many production difficulties blamed either on the metal or on process variables may be reduced or eliminated.

1. The ingot metal should be purchased to specification. Limit the number of sources for such metal and discuss with the sources details of working within specification to secure uniformity of composition from day to day, week to week, and month to month. Such sources should be those able to supply ingot not only of the correct chemical composition but of a cleanliness and quality suitable for the operation.

2. Ingot and scrap should both be melted in a separate melting operation large enough to supply the individual holding pots or furnaces. Such melting should be performed in clean furnaces at temperatures adequate to insure thorough melting and alloying. Clean the walls of these furnaces after every heat, or daily for a continuous operation, and carefully flux the metal so scrapings are eliminated from the bath. For permanent mold casting a degassing operation may be advisable.

3. In the transfer of metal from the melting or breakdown furnace to the holding furnace agitation should be held to a minimum. The spout of a pouring ladle or a pump should be close to the receiving receptacle to avoid foaming. Launders should slope gently to promote quiet flow.

4. The holding pot or furnace should also be kept scrupulously clean. Scrape the walls of either crucible or reverberatory daily and remove the scrapings by a careful fluxing operation.

5. For die castings, solid metal should never be charged into a holding furnace but should be premelted separately either in a central melting furnace, or in an auxiliary melting furnace. For permanent mold casting small proportions of solid metal could be charged into the holding furnace provided the amounts charged were not large enough to cause temperature fluctuation of more than 5 or 10 degrees. Even here it is better to secure absolute temperature control by charging hot.

6. The mold or die should be designed to minimize agitation during pouring. The vertical gating principles of the AFS investigation should be observed for permanent mold casting. A minimum of lubricant with a volatile vehicle is desirable for die casting.

7. Fluxing should be kept to a minimum. At any time there is a viscous scum on the surface of either melting furnace or holding furnace, it should be cut with a suitable flux and the dry powder removed. Such fluxing is advantageous from the standpoint of improved castings and better metal recovery.

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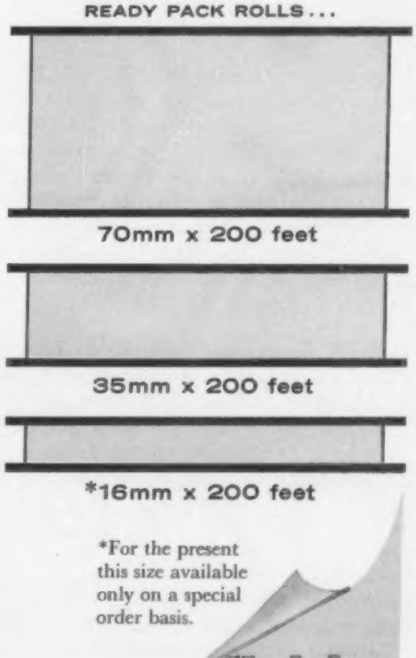

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S. C. Massari

Castings Congress Papers

Progress reports on four AFS-T&RI sponsored investigations bring foundrymen up to date on non-metallic inclusions in cast steel; castability of copper-base alloys; and heavy white iron section casting and annealing. Also: the 5th report on a systematic approach to sand control and design, a rapid method for determining grain refinement, and a permanent mold summary.

TECHNICAL HIGHLIGHTS

Ceroxide Sources and Prevention ....*p 57*
Reaction with ladle refractories is the most serious of the three causes of macroinclusions in steel castings. Elimination may be through use of alumina or magnesia refractories or a newly designed whirl gate trapping system. Design features of the latter include an exit-inlet ratio of 1:1.5, rotation of metal through 270 degrees before passing exit, and extension of the cylindrical section below the exit level.

Refractories as Sources of Macroinclusions.....*p 62*
Silica, fireclay, alumina, and magnesia were selected as to control measures in metal-refractory interactions. Despite the higher cost, the greater stability of alumina and magnesia, should lead to a lower casting cost in steel foundries.

Castability of Copper-Base Alloys ....*p 72*
When risering is possible, aluminum bronze and manganese bronze provide maximum strength and pressure tightness. Present indications are that silicon bronze and 80-10-10 also produce sound castings. The thermal gradients required to produce sound castings in these alloys are less than for 85-5-5-5. In intricate castings, where risering is difficult, the higher tin-lead ratios may be of value in that selected regions may be made pressure tight by chilling.

Casting, Annealing Heavy White Iron Sections..*p 85*
Cerium is capable of producing white fractures at high carbon and silicon percentages where mottle or gray fractures would normally occur. Its effectiveness in raising carbon and silicon limits is similar to that of tellurium, but the percentage required is larger. Investigation shows that when bismuth, tellerium, or cerium are used for prevention of mottling, there is no improvement in the number of nodules during annealing. Those factors which are known to increase nodule number in lighter sections have less effect in heavy sections.

Review of Sand Design, Control Research......*p 93*
The interaction of physical properties clearly show that southern and western bentonite react differently with mulling efficiency, mulling time, and wood flour additives. Wood flour addition to southern bentonite bonded sands reduces the density differential substantially as though less clay was present than actually existed in the mixture. However, western bentonite remains unaffected by wood flour.

Fast Grain Determination Procedure ....*p 98*
A rapid determination of grain size in aluminum and magnesium is possible through a simple cooling curve determination based on supercooling measurement. Using simple techniques and a few precautions, it is possible to use this measurement to estimate the grain diameter of various alloys, or at least to determine if the melt will be coarse grained.

Permanent Mold Practices ....*p 103*
Closer tolerances, superior finish, improved metallurgical characteristics, and higher mechanical properties of permanent molding have contributed to the increasing use of the process. The author evaluates the pressure casting of aluminum cylinder blocks with the permanent mold process.

The technical articles appearing in this preview section of Modern Castings are the official 1961 Castings Congress Papers. Nearly 100 technical papers are scheduled for presentation at the 65th Castings Congress to be held May 8-12 in San Francisco. Readers planning to participate in oral discussion of these papers during the Castings Congress are advised to bring them to the technical sessions for ready reference. Written discussion of these papers is welcomed and will be included in the 1961 AFS Transactions. Discussions should be submitted to the Technical Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

The two papers which follow—"Cast Steel Nonmetallic Macroinclusions Sources and Prevention" by R. A. Flinn, W. B. Pierce and L. H. Van Vlack and "Refractories as Sources of Macroinclusions, An evaluation" by L. H. Van Vlack, J. E. Brokloff and R. A. Flinn are a report of the work which has been done during the past year at the University of Michigan sponsored by the AFS Training and Research Institute and under the direction of the Research Committee of the AFS Steel Division. These studies are a logical continuation of those which the Committee has been directing toward a solution of the problem of macroinclusions in steel castings. These inclusions are those which are called by such names as snotters, ceroxides, etc.

The work which is described in these papers demonstrates with more certainty the mechanism of formation of the defects, and discloses two leads for the prevention of the defects. These are ladle refractories and gating methods. During the coming year, work is planned on field studies to determine the effectiveness of changes in refractories and gating. The Committee is confident that much useful information has been obtained, and is hopeful that the field tests will complete the development of information which will be of considerable benefit to the steel foundryman. John A. Rassenfoss, Chairman, G. A. Colligan, A. J. Kiesler, W. A. Koppi, E. A. Lange, C. H. Lorig, E. Punko, W. R. Punko, D. N. Rosenblatt and J. Zotos.

CAST STEEL NONMETALLIC MACROINCLUSIONS SOURCES AND PREVENTION

Progress Report
Steel Division Research
Sponsored by
AFS Training & Research Institute

by R. A. Flinn, W. B. Pierce and L. H. VanVlack

Part I

ABSTRACT

The nature, causes and prevention of macroinclusions in steel castings have been the subject of a three-year investigation employing laboratory and field research. In previous reports, confirmed by the present work, it has been determined that the most serious type of macroinclusion is composed of corundum crystals in a glassy silicate groundmass. Although this material may be formed (1) during deoxidation of the steel, (2) by reaction with ladle refractories and (3) in the mold itself, reaction (2) is the most serious source.

Present data indicate the inclusions may be eliminated by use of alumina or magnesia refractories, and by a whirl gate trapping system of new design. These indications will be evaluated by further field research.

R. A. FLINN is Prof. of Met. Engrg., L. H. VAN VLACK is Prof. of Ceramics and Met. and W. B. PIERCE is with Dept. of Chemical and Met. Engrg., University of Michigan, Ann Arbor.

INTRODUCTION

For several years the American Foundrymen's Society has sponsored research to determine the causes of large nonmetallic macroinclusions in steel castings. These usually take the form of shallow slag-like masses on cope or vertical surfaces, are usually about one in. in diameter but up to 3 in. and as deep as $\frac{1}{4}$-in. (Fig. 1). These inclusions have also been known as "ceroxides," and by other more descriptive, less delicate terms.

To indicate the position of this paper and its companion[1] in the overall research program, it may be helpful to review briefly the three phase plan deal-

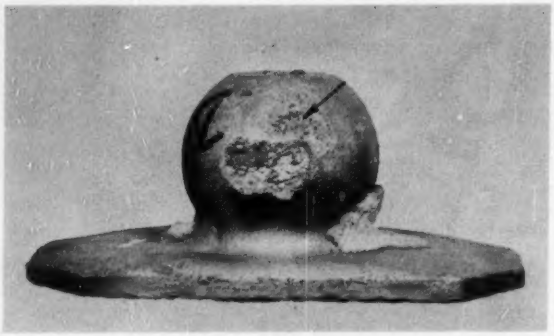

Fig. 1 — Typical nonmetallic macroinclusion on steel casting. The inclusion has been chipped away and moved down disclosing scar on casting. Scale approximately ½ natural size.

ing with macroinclusions which has been followed from the beginning:

1. Determine the nature of the macroinclusions.
2. Determine and evaluate the relative importance of the causes.
3. Develop methods for eliminating the defect.

Nature of Macroinclusions

Since this type of macroinclusion is most prevalent in aluminum deoxidized, green sand castings, this occurrence has received major attention. In other words, since aluminum is widely used to prevent pinholing in green sand castings it seemed important to begin with these inclusions. In castings of this type, the macroinclusions have been identified[2] as silicate glass containing corundum (Al_2O_3) and occasionally hercynite ($FeO \cdot Al_2O_3$) crystals (Fig. 2). Fayalite (Fe_2SiO_4) is often found in the inclusion. However, this is formed during cooling and is not present at the time of casting.

Inclusion Sources

There are three possible sources of the macroinclusions:

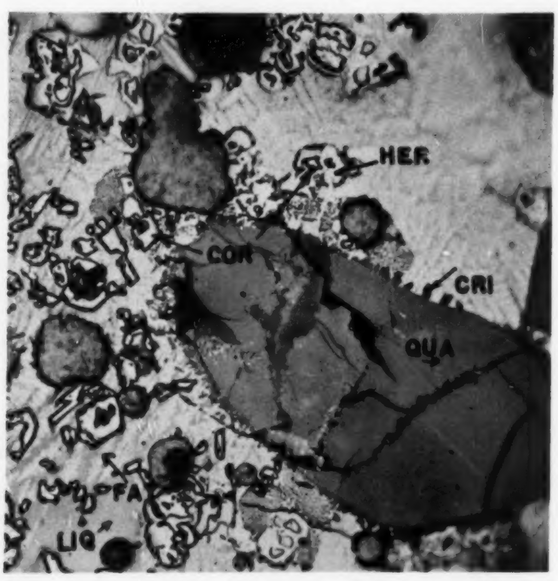

Fig. 2 — Macroinclusion. COR — corundum (Al_2O_3), HER — Hercynite ($FeO \cdot Al_2O_3$), FAY — Fayalite (Fe_2SiO_4), LIQ — Liquid (now glass), QUA — Quartz (SiO_2) from sand, CRI — Cristobalite (SiO_2).

1. Formation during deoxidation of the steel.

   ($\underline{Al} + \underline{O} \rightarrow Al_2O_3$ plus silicates, etc.)

2. Reaction between liquid steel and ladle refractories.

   $(\underline{Al} + SiO_2 \rightarrow \underbrace{Al_2O_3}_{\text{Corundum}} + \underline{Si})$

Other oxides may be formed concurrently (MnO, FeO, etc.).

3. Reaction between liquid steel and mold dirt and sand.

   $(Al + \underbrace{SiO_2}_{\text{excess}} \rightarrow Al_2O_3 + \text{silicates, etc.})$

It has been demonstrated repeatedly[2] that the ladle scum rising after deoxidation, the reaction products on nozzles and other refractories and the macroinclusions in castings are identical in their constituents. Of course the inclusions in the cope surface of the casting will often contain quartz grains from the sand and alteration products as well as the phases just discussed.

After extensive investigation it appears that the inclusions resulting from reaction with ladle refractories are the most troublesome. In tests involving bottom pour ladles, for example, the severity of inclusions increases rather than decreases as a function of holding time in the ladle before pouring. Observation of the metal stream from a teapot or open ladle shows increasing amounts of slag accompanying the metal as time passes.

Attack of the refractory proceeds in the absence of aluminum, by other components of the steel such

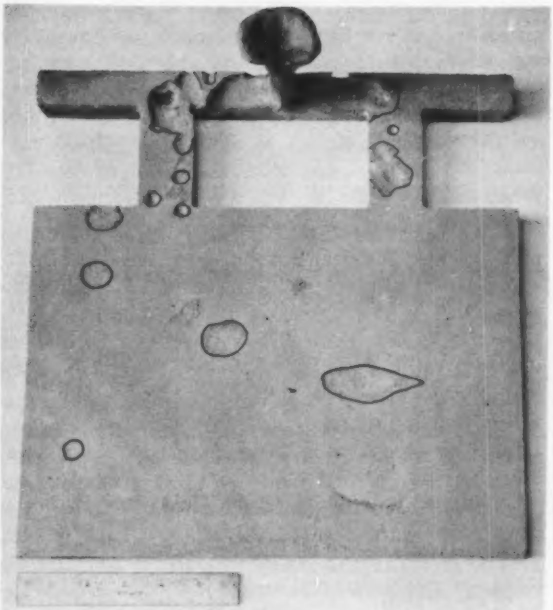

Fig. 3 — Cross gated test casting 10 x 14 x ½-in. showing synthetic inclusions (outlined).

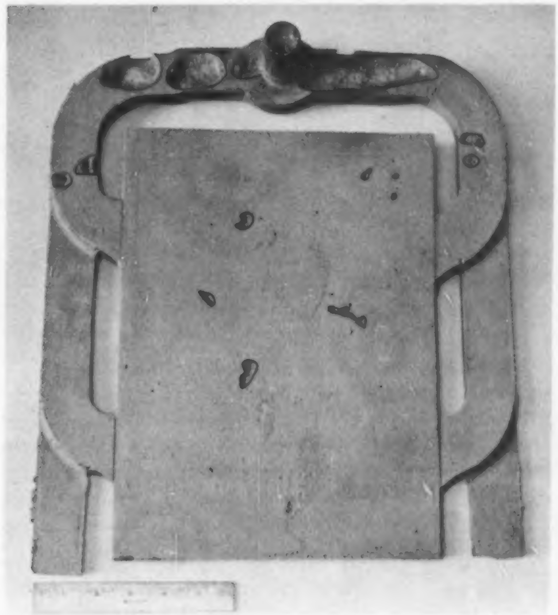

Fig. 4 — Streamline gated test casting 10 x 14 x ½-in. showing synthetic inclusions (outlined).

as iron and manganese. However, the severe inclusions accompanying the presence of aluminum may be related to the effect of the corundum crystals and the alumina in the glassy groundmass of the inclusion in raising its freezing point. Thus, when the inclusion reaches its position in the mold, it is viscous and is not absorbed by the sand. Instead, it protrudes into the metal requiring weld repair.

Elimination of Macroinclusions

As a result of the previous investigation it was decided that three principal courses were open to eliminate this type of macroinclusion.

(A) Eliminate aluminum as a deoxidant. When the aluminum is eliminated or reduced to low levels, <0.02 per cent, inclusions are drastically reduced. Unfortunately, at present aluminum is a specific for pinhole control in green sand castings. Until other deoxidants are developed and generally accepted which do not attack refractories but eliminate pinholes this course must be deferred.

(B) Develop and employ refractories which resist attack. During the past year this phase received major attention as reported in a companion paper.[1] The roles of refractory type, aluminum and manganese contents, time of contact and temperature of liquid steel were investigated. High alumina or magnesia appear superior to fireclay or silica under the more erosive conditions.

It should be pointed out however that, if more resistant refractories are employed, steps should be taken to prevent furnace slag and deoxidation products from building up in the ladle. These can flux the ladle refractories or develop serious accumulations.

(C) Design and test gating systems to trap the inclusions. Since these inclusions are relatively large, it appeared that there was adequate opportunity to trap them in the gating system.

Because of the detailed nature of the work under (*B*) this is reported separately. We can proceed to discuss progress on phase (*C*) as a portion of this paper.

GATING SYSTEMS DEVELOPMENT FOR MACROINCLUSIONS ELIMINATION

Many gating systems have been devised in the past for trapping inclusions, dross and dirt. In this investigation it seemed advisable to select three prin-

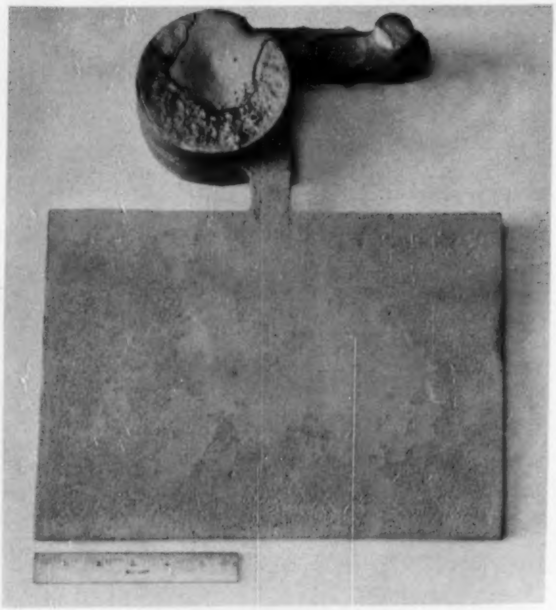

Fig. 5 — Whirl gated test casting 10 x 14 x ½-in. showing trapping of synthetic inclusions (outlined).

cipal types (1) the cross gate, (2) the settling basin with flat gates and (3) the whirl gate or riser.

Cross Gate

The cross gate is intended to trap inclusions by employing a change in metal direction. This is supposed to make it more difficult for the inclusions to follow the metal stream into the mold. A large number of variations in this design have been described in the literature. Among the significant differences are the vertical dimension of the cross gate (runner) compared to the ingots, placing of the runner in the cope ingate in the drag and conversely. The simplest form was used in the preliminary experiments, Fig. 3.

Settling Basin With Flat Gates

In other work sponsored by the American Foundrymen's Society[3] a flat streamlined gating system was developed to prevent dross in aluminum, and has been applied with success to ferrous alloys. It would be expected that a system of this type might trap these macroinclusions in steel. This system is illustrated in Fig. 4. The pertinent details are:

1. A basin at the base of the tapered downsprue with an area five times that of the bottom of the downsprue.
2. Extension of the downsprue below the gate greater than gate height, omitted in the figure.
3. Total gate area from settling basin 4-6 times downsprue area.
4. Casting ingates above the runner.
5. Reduction in runner area on passing ingates.
6. Runner extension beyond last ingate.

The philosophy of this system is to decelerate the metal once it reaches the bottom of the downsprue and allow dross to separate on the wide cope surfaces of the gates. The runner extension is to trap the dross in the first metal passing through the runner system.

Whirl Gate

This system has been described in foreign and U.S. publications, and relies upon centrifugal action to whirl the inclusions to the center of the whirl gate, Fig. 5.

Several design features are important as demonstrated by the experiments to be described. These features are:

1. The area of the exit, i.e., the ingate to the casting must be smaller than that of the inlet so that the metal rises in the whirl and the inclusions are carried above the gate area. A ratio of 1 : 1.5 in area was found desirable.
2. The metal should rotate through at least 180 degrees, and preferably through 270 degrees before passing the exit.
3. To provide additional rotation for the first metal before it enters the mold, the cylindrical section may be extended below the level of the exit.

TEST PROCEDURES

Test castings of several sizes were tried at different stages of the investigation. The change toward larger dimensions was made in the effort to develop a more critical test casting. The sizes used were flat rectangular plates:

A. 5½ x 6½ x ⅜-in.

B. 1 x 4 x 6 in.

C. 8 x 8 x 1 in.

D. 14 x 10 x ½-in.

The effect of size will be discussed under Results.

Synthetic Macroinclusions Use

To provide for rapid testing of the different gating systems, 100 lb 3000 cycle induction furnace heats were made of Grade B steel using the standard rammed magnesia lining. Lip pour ladles lined with fireclay and magnesia were tried in the initial experiments. It was soon determined that it was difficult to produce characteristic large macroinclusions with these techniques, because the time of contact with the lining was insufficient to produce sufficient reaction.

Because of the size of the heat, the time in the ladle could only be of the order of one min compared with 10 to 50 times this period encountered in production heats. Only a few small inclusions were obtained even when the gating system was altered to enter the casting by a simple gate from the base of the downsprue, as in Fig. 6.

It was decided that the deliberate introduction of synthetic macroinclusions in the form of small glass

balls would provide a more severe test to gating traps than the occasional small inclusions encountered in the laboratory. Experiments to be described later indicate that this technique also provides a more severe test than production conditions.

Accordingly, a stream of glass beads about 1/4-in. in diameter is introduced with the metal at the top of the downsprue at the rate of about 15 beads/sec. The beads are of a low melting point sodium glass with a low density comparable to the actual macroinclusions. The beads soften rapidly and pass through the system. They can be found on the cope surfaces, Figs. 3, 4 and 5.

LABORATORY RESULTS

The various gating systems were tried with different plate sizes with these results:

1 x 4 x 6 in. (Type B)	
(1) Cross gate	Inclusions in casting and runner.
(2) Flat gate	No macroinclusions in casting, but present in the runner.
(3) Whirl gate	
270°*	Inclusions trapped completely, casting clean.
180°	Most inclusions trapped, traces of inclusions.
90°	Poor trapping, inclusions in casting.

*Rotation of metal inlet to exit.

The results for the type C plate were essentially the same as for the type B. Finally it was decided to use a larger plate to provide more cope surface and also to permit the use of two ingates per side when the flat gating system was tried, Fig. 4. These castings showed the effects:

Type D (14 x 10 x 1/2-in. plate)	
Cross gate	Inclusions in gates and casting.
Flat gate	Inclusions in gates and casting.
Whirl gate	
270°	Inclusions trapped in whirl, none in castings.
90°	Inclusions in gates and castings.

From these data it was concluded that the 270 degree whirl gate provided a successful trap in all cases. The flat gate was satisfactory for smaller castings but allowed some inclusions to reach the larger casting.

FIELD TESTS

At the present time tests have been made at only one producer, and therefore only tentative conclusions may be drawn.

In the first series of tests molds were made of the type D pattern using the three different gating systems just described. A standard jolt rollover machine and a typical synthetic green sand were employed. Aluminum additions totalling 0.2 per cent were made, 0.15 per cent to the bull ladle and 0.05 per cent to the pouring ladle. The important point is that no macroinclusions were encountered in any of the test plates, gated by the three methods described. However, macroinclusions were obtained in all of small type A plates (Fig. 6) which had simple direct ingates, and which were poured for comparison.

Fig. 6 — Simple ingate on test plate 5½ x 6½ x ¾-in. showing natural inclusions (outlined).

Another heat was poured using simple ingates for the type D plates and characteristic macroinclusions were obtained (no synthetic inclusions were used in these plant tests).

From these tests it may be tentatively concluded:

1. The cross gate, flat gate and whirl gate all are superior to the straight gating system.
2. Under highly critical conditions, simulated by the synthetic macroinclusions, the results from the whirl gate appear best at the present time.

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REFRACTORIES AS SOURCES OF MACROINCLUSIONS

An evaluation

Progress Report
Steel Division Research
Sponsored by
AFS Training & Research Institute

by L. H. Van Vlack, J. E. Brokloff and R. A. Flinn

Part II

ABSTRACT

A companion paper[1] summarizes the work which has been done to date in determining the (a) nature, (b) source and (c) control of macroinclusions in steel castings. One of the important sources is from metal-refractory interaction, and this paper is concerned with the details of this interaction.

This phase of the investigation establishes a test procedure to evaluate refractories for their stability in the presence of molten steel. In addition, consideration is given to the relative effects of (a) metal composition, (b) time and (c) temperature upon the molten metal-refractory reactions. Pertinent conclusions are presented within the report.

Four principal types of refractories were selected for evaluation: silica, fireclay, alumina and magnesia. Although the latter two types are more expensive per pound, it is considered possible that their greater stability might lead to a lower cost per pound of castings shipped.

INTRODUCTION

Molten metals react with many of the commonly available refractories. The consequences are evident in two forms—(a) The refractories are eroded rapidly and therefore lead to high operating costs and production difficulties and (b) The reaction products can be sources of casting imperfections which decrease quality unless specific and expensive repair procedures are used.

The purpose of this work, sponsored by the American Foundrymen's Society Training and Research Institute under the direction of the AFS Steel Division, has been to provide a simple test to analyze the nature and the extent of the reactions between molten steel and foundry refractories.

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PROCEDURE

1. Steels of the desired base composition are melted in a small (60 lb) induction furnace.
2. Final alloy additions are made and the surface slag removed.
3. Small (0.5 x 0.5 in. cross-section) refractory samples are immersed into the steel for a period of 5 min (The furnace power is reduced so as to maintain only slow stirring during the test).
4. The characteristic reaction is observed at the surface below the metal line.
5. The necessary precautions are only those that would be anticipated on the basis of common metallurgical practices such as—melting, oxidation, slag-off and power supply.

As previously reported,[2,3] it is possible to observe reactions between refractories and molten steel on the basis of the laboratory test scheme, shown in Fig. 1.

The refractory sample is prepared by:

1. The refractory to be tested is cut from a brick, nozzle, or other source so that the dimensions of 0.5 x 0.5 x 4 in. are available.
2. These are mounted into slots cut out of a soft insulating brick holder. A fireclay mortar slurry is used for cementing purposes.
3. Two or more samples (e.g., the current refractory for reference, plus new refractories) may be tested concurrently. The holder and cement do not contact the melt.

The results of testing are shown in Fig. 2. The severity of the reaction is classified from 0 (none)

to 5 (complete erosion). The nature of the reaction varies from a liquid product which is easily absorbed by a porous ladle or mold refractory, through a semi-viscous glass, to a solid oxidation product which accumulates on the refractory surface. The notations of (p), (v) and (a) are given in Fig. 2 for the products which are respectively absorbed into the pores (p) as a fluid liquid, carried with the moving metal as a viscous (v) liquid or accumulated (a) on the surface as a solid accretion. The region of greatest significance is the tip or the part of the test sample that was most deeply immersed.

The requirements and precautions of the test involve a specified time, avoidance of excessive surface accumulations on the molten metal and of excessive oxidation. Five min exposure has proved to be satisfactory, because the 0.5 x 0.5 in. refractory is heated sufficiently for the reaction to proceed to a satisfactory extent. Additional time reveals little additional information. Surface accumulations on the molten metal of fluxed refractory or oxidation products must be removed during the course of the test.

This is particularly true when more than one type of sample is being tested, because reaction products from one type of sample may mask the surface of the neighboring sample. Excessive oxidation of the melt during the test will produce extra FeO at the surface, and can mislead the inexperienced analyst. Therefore, it is recommended that the surface of the molten steel be covered with tank nitrogen during the course of the test from the time of alloy additions until completion.

RESULTS

The results of experiments using the test procedure just described corroborate information which has been observed in previous plant experience. In addition, it has led to an indication of the relative significance of several contributing factors in refractory erosion. These will be summarized in the balance of the paper. Table 1 summarizes the test data and Table 2 condenses the results.

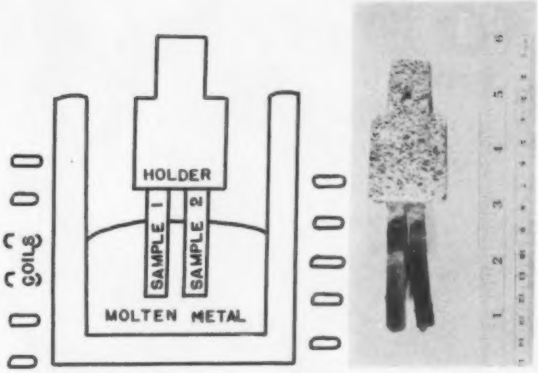


Fig. 1 — Experimental procedure. *Left* — schematic *right* — sample after testing. Direct contact was made between molten metal and refractory samples. Preference is given to the use of a nitrogen blanket over the metal. However, air may be used if samples are deeply immersed in metal so surface oxides are avoided.[3]

Aluminum Effect

The interaction of dissolved aluminum and refractories was described previously.[3] In review, fireclay refractories are most severely affected. A viscous reaction product is formed which is subject to erosion by the metal stream (Fig. 3). Silica refractories are less severely affected. The product is more fluid and is absorbed by the refractory. Refractories with alumina higher than that found in fireclay form a solid reaction product which is not eroded by the metal stream, and may even be subject to surface accumulation.

Fig. 2 — Rating of refractory reaction in molten metal. Line in figure represents the metal line. *Left to right* — *1p* — slight fluxing, fluid liquid is absorbed into refractory pores; *2p* — fluxing, fluid liquid is absorbed into refractory pores; *2v* — fluxing, a viscous liquid product is formed; *3v* — extensive reaction and fluxing, a viscous liquid is formed; *3a* — extensive reaction and accumulation of a solid reaction product; *4v and 5v* — severe fluxing and erosion.

TABLE 1 — MELTING DATA

Heat	Temp., F	Time, min	Analysis, % C	Si	Mn	Al	Aim, % Al
F-42	2830	10	0.38	0.36	0.37	—	—
F-43	2970*	10	0.36	0.38	0.42	—	0.2
F-44	2850	5	0.33	0.41	0.36	—	—
F-45	2845	5	0.31	0.45	0.38	0.21	0.2
F-46	2960	5	0.28	0.49	0.35	0.21	0.2
F-47	2840*	5	0.31	0.22	0.25	—	—
F-48	2850*	5	0.31	0.33	0.30	—	—
F-49	2880*	5	0.29	0.51	0.36	—	—
F-52	2845*	5	0.33	0.41	3.28	—	—
F-53	2850*	5	0.30	0.47	3.26	>0.04	0.2
F-54	2960*	5	0.28	0.51	3.28	0.04	0.2
F-55	2845*	10	0.34	0.41	2.79	—	—
F-56	2950*	10	0.30	0.45	2.71	0.05	0.2

*Temperatures by immersion thermocouple, others by optical pyrometer.

TABLE 2 — SUMMARY OF RESULTS (Figs. 2 and 4)

		I	II	III	IV	V
Temperature, F		2850	2950	2950	2850	2850
Time of contact, min		5	5	10	5	10
Aluminum		yes	yes	yes	no	no
Refractory	Manganese (%)					
S Silica	Lo Mn(0.5)	1*	1	3	1	2
	Hi Mn(2.75)	4-5	4-5	4-5	4-5	4-5
F Fireclay	Lo Mn(0.5)	1a	1a	4	2	3
	Hi Mn(2.75)	3a	4-5	4-5	4-5	4-5
A Alumina	Lo Mn(0.5)	0	0	0a	0	0
	Hi Mn(2.75)	0a	1	2a	1a	1
M Magnesia	Lo Mn(0.5)	0	0	0a	0	0
	Hi Mn(2.75)	0a	1a	1	0a	0a

* See Fig. 2 for notation.

Manganese Effect

The role of manganese varies with other factors. These are presented in Figs. 5-9 and summarized in Fig. 4. However, each will be given individual attention.

Figure 5 — Effect of manganese (with no aluminum, 2850 F and standard time). Fireclay refractories are affected more than other types at low manganese levels, while silica refractories are affected most severely at high manganese levels. Alumina and magnesia refractories are subject to negligible reaction at levels up to 3-4 per cent manganese. In contrast, they will accumulate metal oxidation products on their surfaces.

Figure 6 — Effect of manganese (with no aluminum, 2850 F and longer times). The reactions are increased as compared with standard times, otherwise the relative relationships described in the previous paragraph are applicable.

Figure 7 — Effect of manganese (with aluminum deoxidation, 2950 F and standard time). Manganese in-

Fig. 3 — Corundum (COR), Al_2O_3, is formed as a reaction product between the aluminum in the molten steel and the oxygen in the refractories and steel. Liquid (LIQ) is now glass.[3]

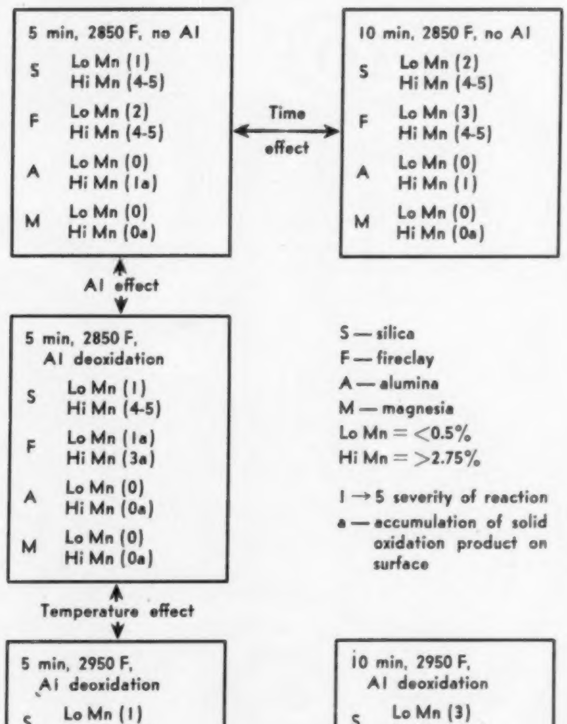


Fig. 4 — Summary of the role of manganese as it varies with other factors, as presented in Figs. 5 - 9.

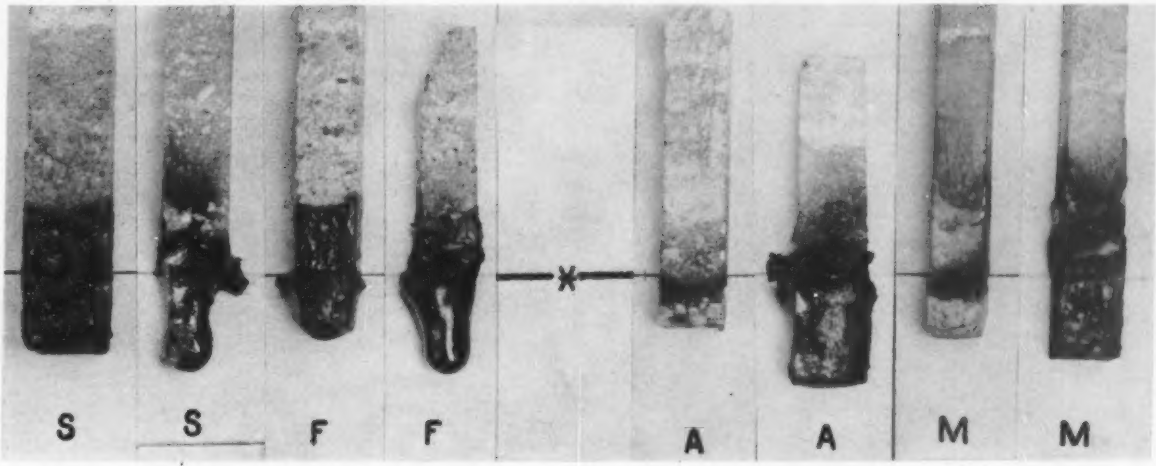
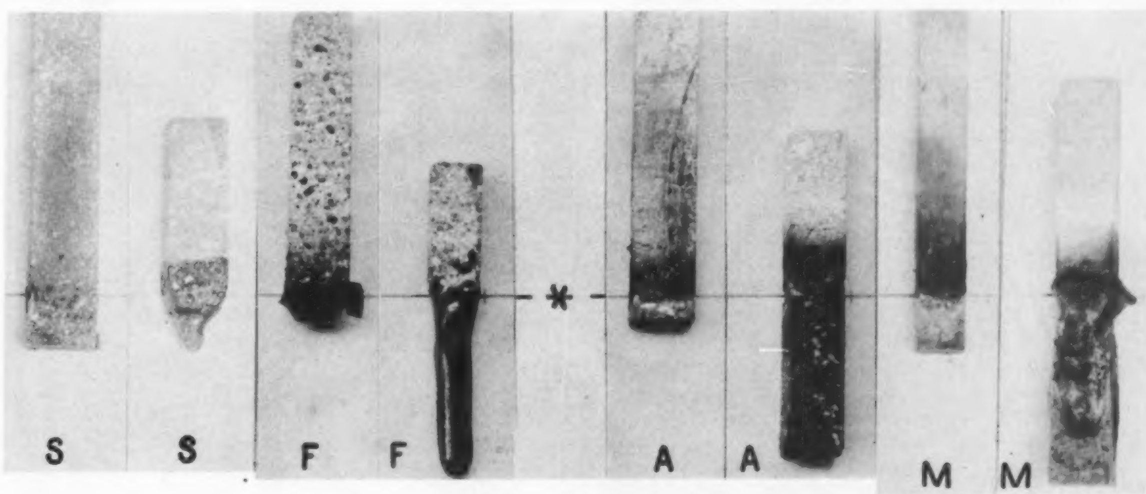


Fig. 5 — Manganese content variable, temperature (2850 F) and aluminum content (none) fixed (Table 1 presents exact data). Contact time — 5 min. * = metal line. a = accumulation of oxidation product on sample surface.

Position / % Mn / Test / Refractory	Left	Right
% Mn	0.36	3.28
Test	F-44	F-52
S - silica	1	4-5
F - fireclay	2	4-5
A - alumina	0	1-a
M - magnesia	0	0-a

Fig. 6 — Manganese content variable, temperature (2850 F) and aluminum content (none) fixed (Table 1 presents exact data). Contact time — 10 min. * = metal line. a = accumulation of oxidation product on sample surface.

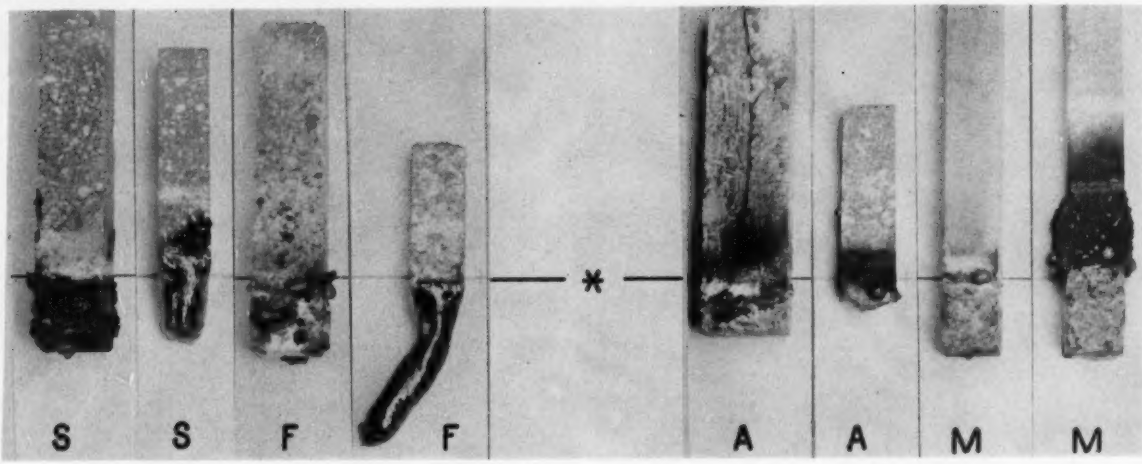


Position / % Mn / Test / Refractory	Left	Right
% Mn	0.37	2.79
Test	F-42	F-55
S - silica	2	4-5
F - fireclay	3	4-5
A - alumina	0	1
M - magnesia	0	0-a

creases the reaction. At low manganese levels, a solid reaction product is formed as a result of the aluminum deoxidizer.

Figure 8 — Effect of manganese (with aluminum deoxidation, 2950 F and longer times). The increased time increases total attack, otherwise the relative relationships are comparable.

Figure 9 — Effect of manganese (with aluminum deoxidation, 2850 F and standard time). The reaction gives less liquid and more solid (with corundum and spinel) than shown in Fig. 5 without aluminum



Position / % Mn / Test / Refractory	Left 0.35 F-46	Right 3.28 F-54
S - silica	1	4-5
F - fireclay	1-a	4-5
A - alumina	0	1-x
M - magnesia	0	1-a

Fig. 7 — Manganese content variable, temperature (2950 F) and aluminum deoxidation fixed (Table 1 presents exact data). Contact time 5 min. * = metal line. a = accumulation of oxidation product on sample surface. x = sample broke during test.

deoxidation. Otherwise the results are comparable. Aluminum must be added for corundum to be present. There is no solid accumulation on magnesia refractories unless both aluminum and manganese are added.

Temperature Effect

The role of temperature was examined at 2850 F and 2950 F. Above 3000 F the silica and fireclay refractories melt from the temperature alone, and do not require additional reactions for failure. Although in normal practice tapping temperatures are greater, these represent characteristic ladle temperatures.

Figure 10 — Effect of temperature (with aluminum deoxidation; low manganese and standard time). An increase in temperature from 2850 F to 2950 F shows little effect when the manganese is low (<0.5 per cent).

Figure 11 — Effect of temperature (with aluminum deoxidation and standard time). Temperature has little effect on the attack on the silica in the 2850 F to 2950 F range. It does have some effect upon fireclay, indicating that the solid reaction products are being fluxed.

Time of Contact Effect

The effect of the time of contact is one of aggravating the reaction. No new nor change in reactions is found.

Figure 12 — Effect of time of contact (with no aluminum, 2850 F and low manganese). Only minor differences in the amount of reaction for periods up to 10 min.

Figure 13 — Effect of time of contact (with no aluminum, 2850 F and high manganese). The time has appreciably less effect than the increase in the amount of manganese.

Figure 14 — Effect of time of contact (with aluminum deoxidation, 2950 F and low manganese). A slight effect of the added time can be observed.

Figure 15 — Effect of time of contact (with aluminum deoxidation, 2950 F and high manganese). The effect of time is masked by the effect of the manganese.

Alloy Source

Figure 16 — Effect of Ca-Mn-Si alloy as a source of manganese. As long as the amount of manganese stays the same, the presence of calcium and silicon as alloy additions provides no change in the amount of reaction between the metal and any of the refractories. As previously noted, the variation between refractories is evident.

Reaction Products

A glassy reaction product is formed when silica brick is attacked by steel. Either aluminum or manganese will accentuate the amount of glass. In the case of firebrick, the reaction product which is formed is more affected by the composition of the steel than

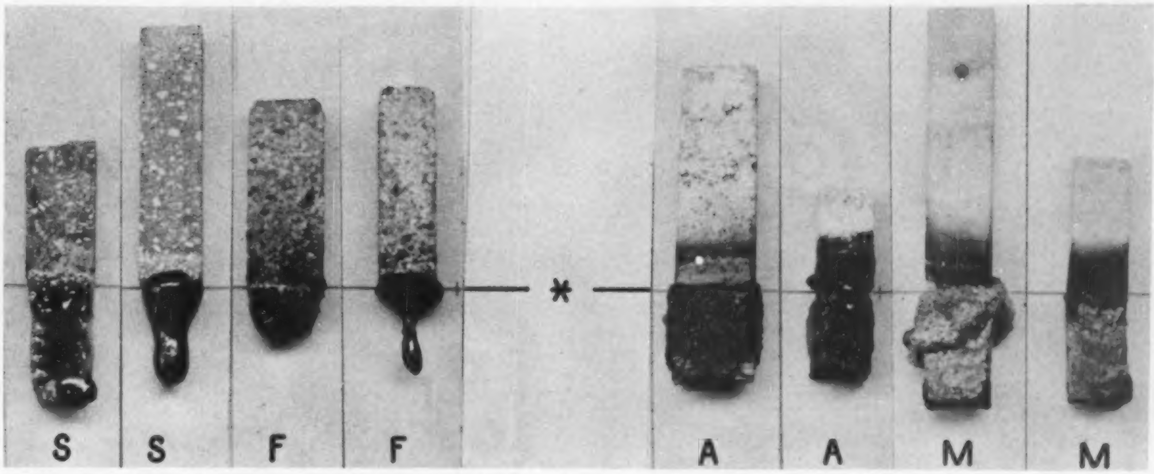
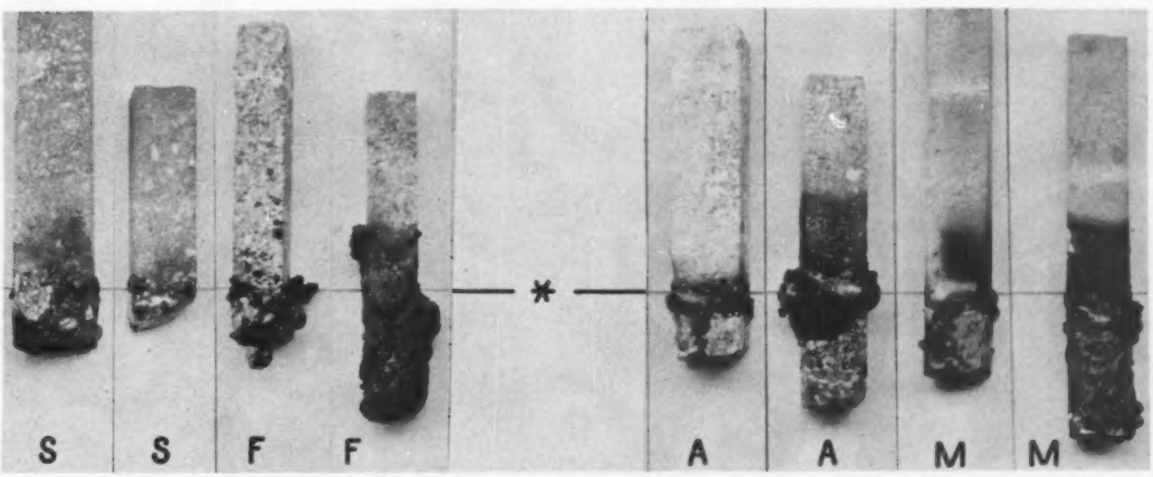


Fig. 8 — Manganese content variable, temperature (2950 F) and aluminum deoxidation fixed (Table 1 presents exact data). Contact time — 10 min. * = metal line. a = accumulation of oxidation product on sample surface.

Position / Refractory	Left	Right
% Mn	0.42	2.71
Test	F-43	F-56
S - silica	3	4-5
F - fireclay	4	4-5
A - alumina	0-a	2-a
M - magnesia	0-a	1

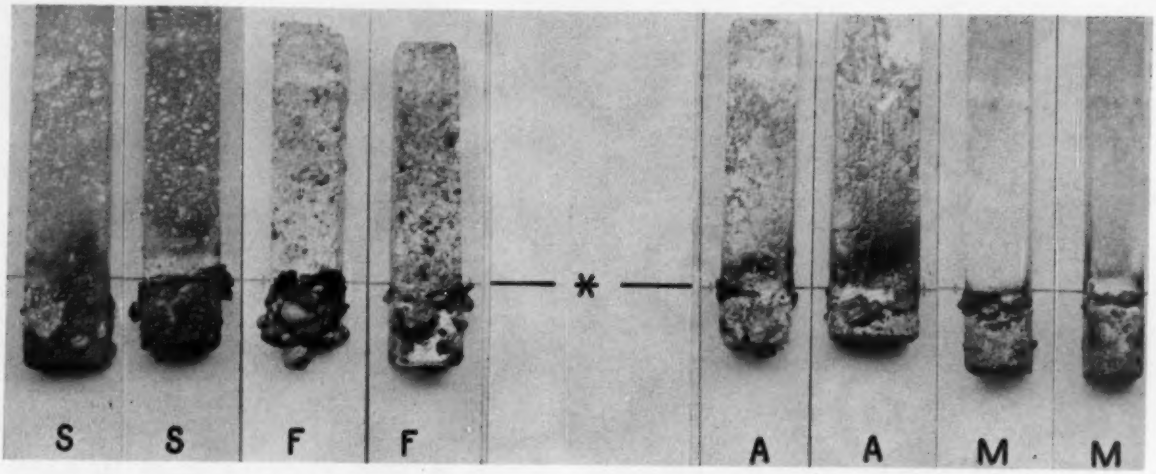
Fig. 9 — Manganese content variable, temperature (2850 F) and aluminum deoxidation fixed (Table 1 presents exact data). Contact time — 5 min. * = metal line. a = accumulation of oxidation product on sample surface.



Position / Refractory	Left	Right
% Mn	0.38	3.26
Test	F-45	F-53
S - silica	1	4-5
F - fireclay	1-a	3-a
A - alumina	0	0-a
M - magnesia	0	0-a

in the case of the silica-steel reaction. Manganese will produce a low melting glass. Aluminum produces a more viscous glass which contains corundum (Al_2O_3) crystals (Fig. 3). The latter are not encountered in the absence of aluminum additions, because they are formed by aluminum reacting with oxygen in the refractories and in the steel.

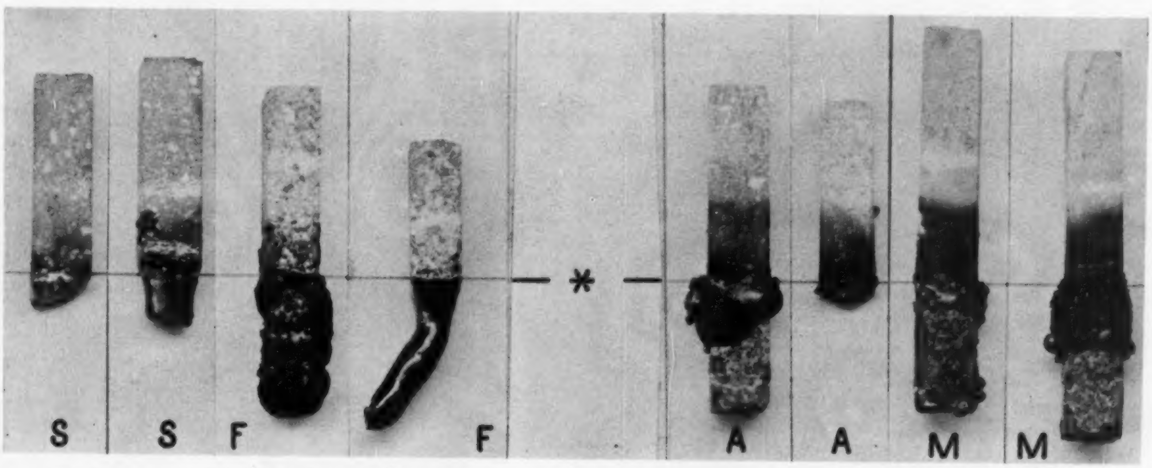
Higher alumina brick (more than the typical 35 per cent Al_2O_3 which is present in fireclay refractories) are not subject to alteration by molten steel unless high amounts of manganese are present. In



Position / Temperature / Test / Refractory	Left 2850°F F-45	Right 2950°F F-46
S - silica	1	1
F - fireclay	1-a	1-a
A - alumina	0	0
M - magnesia	0	0

Fig. 10 — Temperature variable, low manganese (<0.5%) and aluminum deoxidation fixed (Table 1 presents exact data). Contact time — 5 min. * = metal line. a = accumulation of oxidation product on sample surface.

Fig. 11 — Temperature variable, high manganese (>2.75%) and aluminum deoxidation fixed (Table 1 presents exact data). Contact time — 5 min. * = metal line. a = accumulation of oxidation product on sample surface. x = sample broke during test.



Position / Temperature / Test / Refractory	Left 2850°F F-53	Right 2950°F F-54
S - silica	4-5	4-5
F - fireclay	3-a	4-5
A - alumina	0-a	1-x
M - magnesia	0-a	1-a

this case, galaxite ($MnO{\cdot}Al_2O_3$) is encountered. This mineral is a member of the spinel family and similar in appearance to hercynite ($FeO{\cdot}Al_2O_3$) previously described.[3]

Magnesia refractories are not altered by MnO nor FeO. In an isolated instance, the mineral, spinel ($MgO{\cdot}Al_2O_3$) was observed as the result of a solid reaction with the alumina deoxidation product.

When aluminum and manganese are both present in the steel, galaxite ($MnO{\cdot}Al_2O_3$) is encountered as a deoxidation product. This will form as an accretion on both magnesia and high alumina refractories.

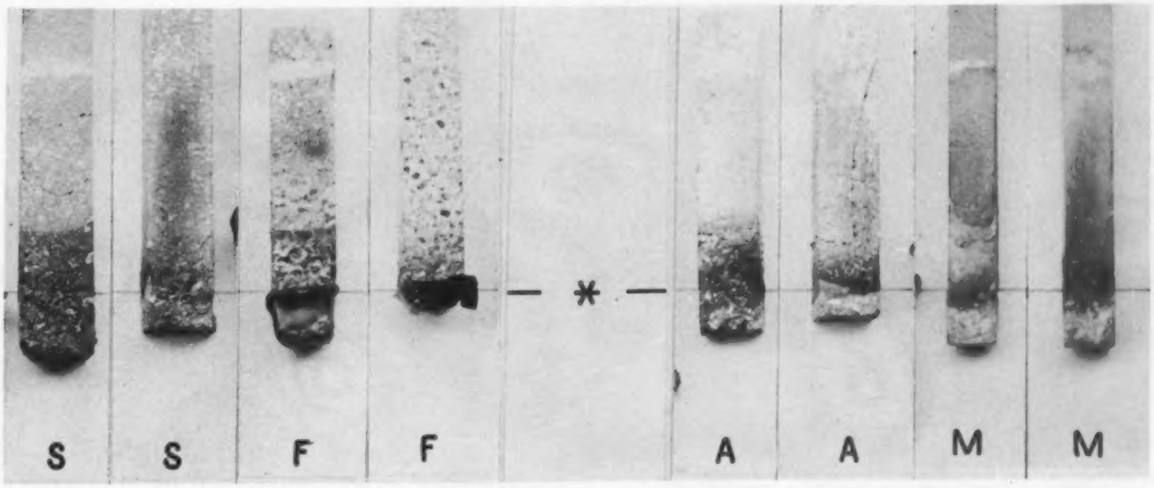
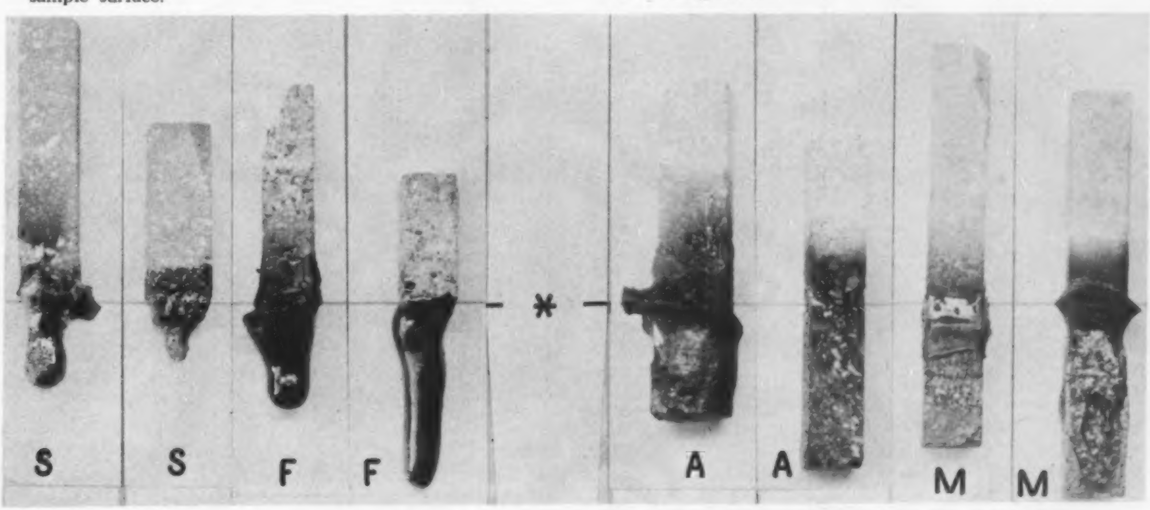


Fig. 12 — Time of contact variable, temperature (2850 F), aluminum content (none) and low manganese (<0.5%) fixed (Table 1 presents exact data). * = metal line.

Position / Time / Test / Refractory	Left 5 min. F-44	Right 10 min. F-42
S - silica	1	2
F - fireclay	2	3
A - alumina	0	0
M - magnesia	0	0

Fig. 13 — Time of contact variable, temperature (2850 F), aluminum content (none) and high manganese (>2.75%) fixed (Table 1 presents exact data). * = metal line. a = accumulation of oxidation product on sample surface.



Position / Time / Test / Refractory	Left 5 min. F-52	Right 10 min. F-55
S - silica	4	5
F - fireclay	4	4
A - alumina	1-a	1
M - magnesia	0-a	0-a

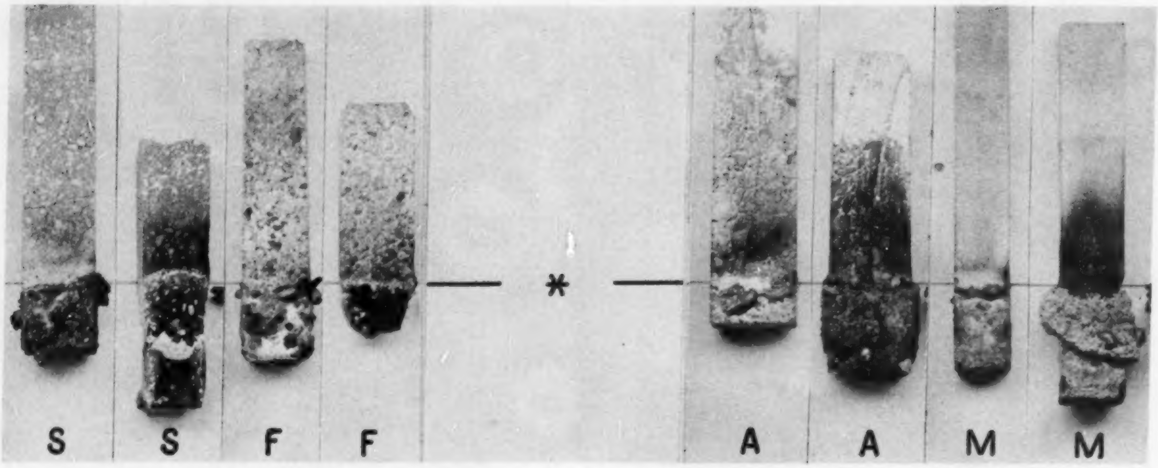
The reaction product from Ca-Mn-Si deoxidation is a glass.

CONCLUSIONS

A test procedure for refractory-metal reactions is presented.

The conclusions concerning reactions are summarized by Fig. 4 and Table 2. These include:

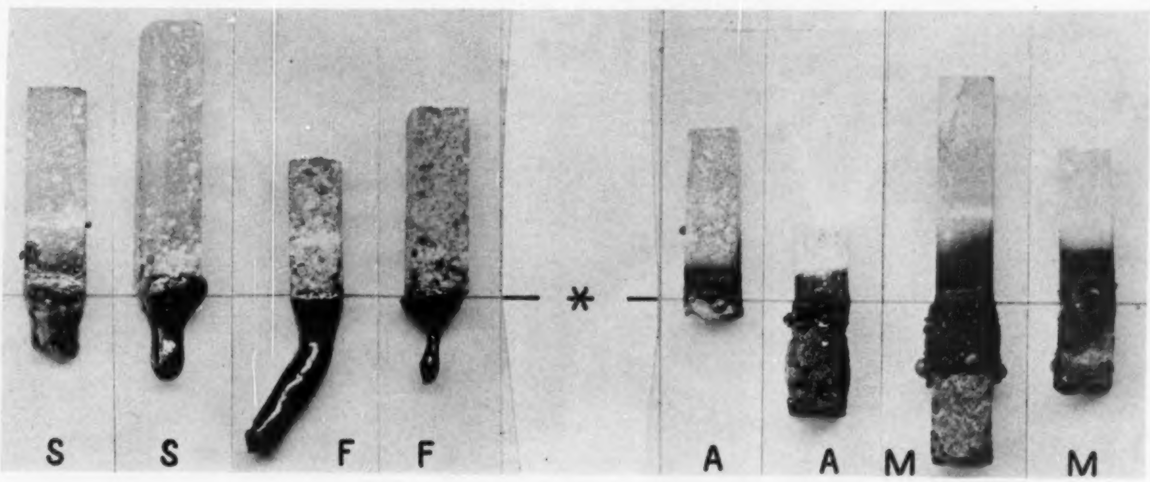
1. Aluminum produces a reaction product on fireclay refractories that is identical with the macroinclu-



Position / Time / Test / Refractory	Left 5 min. F-46	Right 10 min. F-43
S - silica	1	3
F - fireclay	1-a	4
A - alumina	0	0-a
M - magnesia	0	0-a

Fig. 14 — Time of contact variable, temperature (2950 F), aluminum deoxidation and low manganese (<0.5%) fixed (Table 1 presents exact data). * = metal line. a = accumulation of oxidation product on sample surface.

Fig. 15 — Time of contact variable, temperature (2950 F), aluminum deoxidation and high manganese (>2.75%) fixed (Table 1 presents exact data). * = metal line. a = accumulation of oxidation product on sample surface. x = sample broke during test.



Position / Time / Test / Refractory	Left 5 min. F-54	Right 10 min. F-56
S - silica	4-5	4-5
F - fireclay	4-5	4-5
A - alumina	1-x	2-a
M - magnesia	1-a	1

sions which cause the casting imperfections. This may temporarily protect the refractory at low temperatures until it is removed by erosion into the metal stream.

2. Manganese accentuates the fluxing reaction at the refractory surface. It does not produce corundum unless aluminum is also added to the steel.
3. Silica and fireclay refractories are both subject to severe fluxing reactions at high manganese levels (>2.75 per cent). Alumina and magnesia refractories are essentially immune to the reactions under the range of the conditions tested.

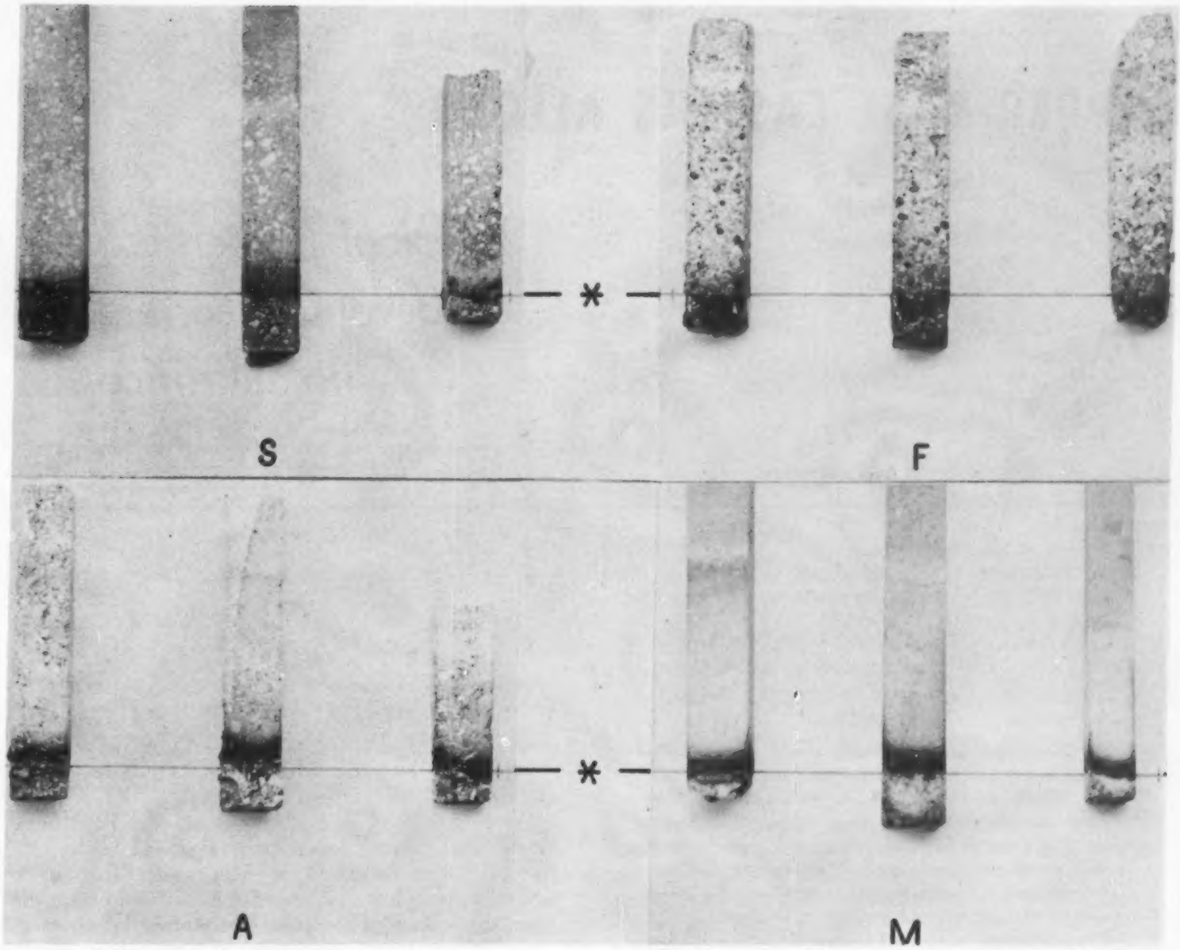


Fig. 16 — Ca-Mn-Si addition variable, temperature (2850 F), aluminum content (none) and low manganese (<0.5%) fixed (Table 1 presents exact data). Contact time — 5 min. * = metal line.

Position / Ca-Mn-Si Test / Refractory	Left none F-47	Middle 3 lb/T F-48	Right 9 lb/T F-49
	←	Equal Mn	→
S - silica	1	1	1
F - fireclay	2	2	2
A - alumina	0	0	0
M - magnesia	0	0	0

4. At low manganese levels (<0.5 per cent), fireclay refractories are more subject to reaction with molten steel than are silica refractories. At high manganese levels, at 2850 F, the initial attack of the silica is greater.
5. Temperature variation in the range of 2850-2950 F has relatively minor effect upon the reactions. There is one exception. The reaction product (Conclusion 1) is fluxed more severely at higher temperatures and therefore the refractories are more easily eroded (temperatures in excess of 3000 F for fireclay and silica would alter this conclusion because these refractories could be melted without any reaction).
6. Time of contact has a minor but noticeable effect at low manganese levels. At high manganese levels, reaction is severe even in brief intervals of contact.

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COPPER-BASE CASTING ALLOYS

Physical properties and void volume correlation with solidification

Progress Report
Brass and Bronze Division
Sponsored by
AFS Training & Research Institute
by R. A. Flinn and H. Kunsmann

ABSTRACT

The castability of copper-base alloys with a wide range of liquidus-solidus intervals has been investigated. These include 80-10-10, 85-5-5-5, 88-8-0-4, aluminum bronze, manganese bronze, silicon brass and nickel silver. Using the end-chilled 12 x 2 x 2 in. test bar previously developed, the variation in density, leakage, microstructure and mechanical properties has been measured as a function of position in the bar.

The aluminum bronze and manganese bronze showed little variation in density, no leakage or microshrinkage and little change in mechanical properties. Surprisingly, the 80-10-10 and the silicon brass, materials with the longer liquidus-solidus intervals, also showed similarly good castability. The other mushy-type freezing alloys exhibited leakage, low density, microshrinkage and poorer mechanical properties at the stations in the bar well away from the chill. A mechanism relating the large volume of low melting point liquid in the silicon bronze and the 80-10-10 to the morphology of solidification is proposed.

INTRODUCTION

In previous work in this investigation sponsored by the AFS Training and Research Institute under the direction of the AFS Brass and Bronze Division Research Committee,[1] the immediate objective of the research program was to determine the conditions affecting the pressure tightness of 85-5-5-5 castings. The initial effort was directed toward this single objective because of the predominant use of this alloy and the widespread interest in the variables affecting leakage. As a result of this work it was established[1] that, to produce pressure tight sections, a strong thermal gradient (60 F/in.) was required during the final stages of solidification of the matrix. A variety of shapes, section sizes, chill and riser designs was investigated to determine the thermal gradients and soundness of the castings.

Upon the conclusion of this work the committee agreed that further investigations should follow two paths—(1) determination of the conditions of solidification necessary for development of maximum physical properties (including pressure tightness) in other copper-base alloys and (2) application of the solidification data to problem castings to illustrate their use to the foundryman. This paper is concerned only with phase one; the work dealing with problem castings is underway and will be reported at a later date.

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PROCEDURE

Most of the procedure follows the methods developed and described previously.[1] Important procedural additions were made, however.

Alloys Investigated

In order to provide a wide range of alloys with different solidification intervals these analyses were selected for the first phase of the work:

B30 A.S.T.M. Class	Composition, % Cu	Sn	Al	Pb	Fe	Zn	Ni	Si	Metal Type	Freezing Range, F
1 B	88	8	—	—	—	4	—	—	Modified G Bronze	270
3 A	80	10	—	10	—	—	—	—	High Leaded Tin Bronze	302
4 A	85	5	—	5	—	5	—	—	Leaded Red Brass	260
8 A	58	—	1	—	1	39	—	—	Manganese Bronze	30
9 B	89	—	10	—	1	—	—	—	Aluminum Bronze	15
11 A	64	4	—	4	—	8	20	—	Nickel Silver	250
13 A	81	—	—	—	—	15	—	4	Silicon Brass	

TABLE 1 — CHEMICAL ANALYSES OF THE ALLOYS[1]

A.S.T.M.	3 A 80-10-10	1 B 88-8-0-4	4 A 85-5-5-5	8 A Mn Bronze	9 B 89-1-10	11 A Ni Silver	13 A Si Brass
Cu	79.24	86.98	84.2	58.45	88.66	(64.67)	82.85
Sn	9.45	8.07	4.7	0.45	—	(3.97)	—
Pb	9.97	0.11	5.1	0.23	—	(3.83)	Tr.
Zn	bal (0.6)	bal (4.20)	bal (5.08)	bal (38.67)	—	bal (6.36)	bal (13.0)
Fe	0.015	0.08	0.16	0.92	1.15	0.92	0.08
Al	—	—	<0.01	0.38	10.00	—	—
Mn	—	—	0.0	0.30	—	—	—
Ni	0.39	0.55	0.54	—	—	(20.08)	—
Sb	0.27	—	0.20	—	—	0.17	—
P	—	0.011	0.01	—	—	—	4.02
Liquidus, F	1705[3]	1840[4]	1830	1690[3]	1915[4]	2100[5]	1683[3]
Solidus,[2] F	1403[3]	1570[4]	1570	1660[3]	1900[4]	1850[5]	1510[3]
Range, F	302	270	260	30	15	250	173

1. Average of analyses from heats 50 and 52.
2. Solidus of α phase, not of lead rich eutectic.
3. From Brass and Bronze Ingot Institute data for alloys of this type.
4. From binary diagram approximation.
5. From International Nickel Co. literature.

The ingot analyses are listed in Table 1.

Melting Procedure

The alloys were melted in a gas fired crucible furnace, with the exception of several induction melts. The melts were superheated to 300 F above their respective liquidus temperatures, and poured at 200 F above the liquidus. Standard deoxidation practices were followed, and no evidence of gas porosity was encountered.

Test Casting

The standard 12 x 2 x 2 in. bar chilled at one end face, which had been developed in previous work, was poured in dry sand molds. In determining solidification patterns, thermocouples were placed at the centerline of the bar at 1, 3, 5, 7, 9 and 11 in. from the chilled end. A six point recorder with a one sec full scale response was employed.

In order to supplement the thermocouple data a number of castings were drained at a predetermined time during solidification. This was accomplished by tilting the mold 90 degrees and allowing the liquid to escape through the riser.

Sectioning of Test Castings

Leakage test. A longitudinal slice $\frac{1}{32}$ x 2 x 12 in. was machined from the center plane of the bar for pressure testing, as in Fig. 1. The leak rate of compressed air at 100 psi through a $\frac{1}{2}$-in. diameter orifice held at the centerline was determined at different locations along the bar.

Density. Density specimens were taken at various locations, as shown in Fig. 1. In all cases the surfaces were ground free of sand and scale. The density was determined using an analytical balance and distilled water containing aerosol.

Tensile specimens. These specimens were cut just beneath the center plane of the bar, as shown in Fig. 1. The dimensions of the specimen are shown in Fig. 2.

Microspecimens. The locations of the specimens are shown in Fig. 1. The specimens were mounted in bakelite and polished using metallographic papers and diamond paste. Because of the necessity of dis-

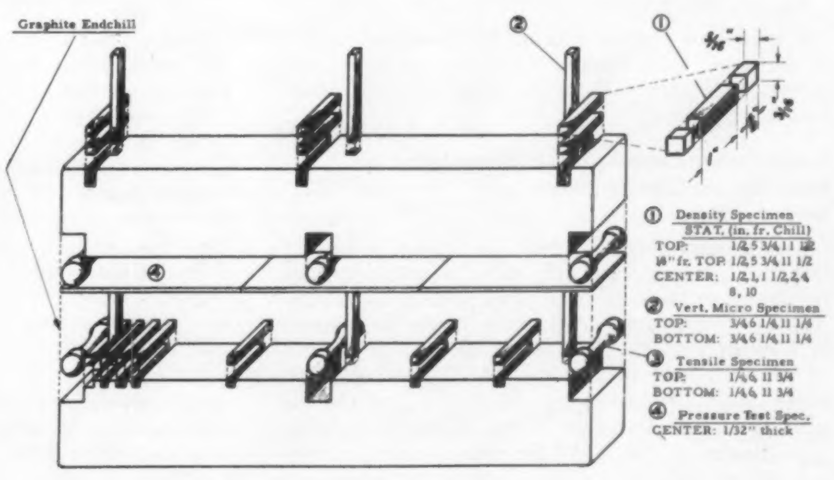


Fig. 1 — Exploded view of 2 x 2 x 12 in. standard test bar to indicate specimen locations.

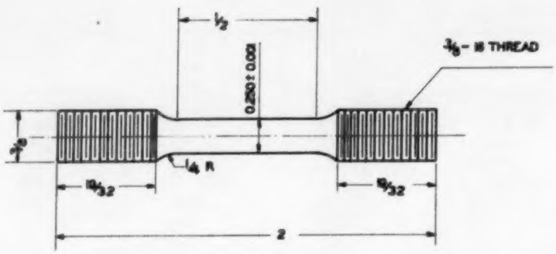


Fig. 2 — 0.250 in. tensile specimen.

tinguishing between lead and shrinkage voids, special care was taken to use low nap polishing wheels and a minimum of fluid in polishing.

EXPERIMENTAL DATA

Because of some of the complex relations among the different sets of data, it is advisable to present the data separately under these divisions and then discuss their interrelations:

1. Variation in physical properties including pressure tightness as a function of position in the test bar.
2. Solidification patterns of the different alloys as disclosed by cooling curves and drainout experiments.
3. Metallographic examination.

Variation in Properties as a Function of Position in the Test Bar

The data for all the alloys are summarized in Fig. 3. By employing a common abscissa for mechanical properties, density and leak rate the following general relations are made evident. The compositions may be divided into two principal groups according to the results:

1. No leakage, no appreciable variation in density and only minor variations in mechanical properties along the test bar. These alloys are—3 A—80-10-10, 8 A—Mn bronze, 9 B—Al bronze and 13 A—Si brass.
2. Leakage in portions of the test bar away from the chill and corresponding decreases in density and mechanical properties. These alloys are—1 B—88-8-0-4, 4 A—85-5-5-5 and 11 A—nickel silver.

It is obvious that there is not the usual correlation of soundness with freezing range as commonly expected. This point will be discussed after the other data are presented.

Solidification Patterns of Different Alloys as Disclosed by Cooling Curves and Drainout Experiments

Cooling curves. The cooling curves may be divided into two general classes—(1) those in which a large portion of the solidification takes place at practically constant temperature, particularly in the final stages of freezing and (2) those in which a large portion of the solidification takes place over a wide temperature range, particularly in the final stages. On the basis of this classification, the alloys may be divided, as indicated in Fig. 5, by schematic cooling curves:

Class 1.
(3 A—80-10-10).
8 A—Mn bronze.
9 B—Al bronze.
13 A—Si brass.

Class 2.
1 B—88-8-0-4.
4 A—85-5-5-5.
11 A—nickel silver.

It will be noted that in this arrangement the alloys of Class 1 are the same as those showing no leakage, while those of Class 2 show a decrease of properties away from the chill (placing the 3A alloy in Class 1 is controversial, as discussed later, since the data for the freezing of the lead-tin phase are not available).

Cooling curves provide interesting data relevant to solidification morphology, but do not generally indicate the time for initiation of freezing at given thermocouple locations. Consider, for example, the beginning of the arrest at the No. 3 thermocouple in the 89-1-10 bar, Fig. 4c. At this location the heat transfer is essentially unidirectional because of the nearness of the end chill. When this station reaches the liquidus temperature there is a thermal block to heat transfer, because the metal between it and the chill is also at the liquidus. The No. 2 couple, for example, is also at the liquidus temperature and does not complete freezing for 120 sec.

Only after the temperature at No. 2 falls below the liquidus can heat transfer, and hence freezing take place at No. 3. Another procedure was therefore used to provide additional information as described in the drainout experiments.

Drainout experiments. To supplement the cooling curve data, it was decided to determine the flowability of the metal at a given time at different distances from the solidifying interface. In other words, it was hypothesized that if, in a given alloy, fluid metal existed close to the finally solidifying interface this would lead to a sound surface compared to the case where an extensive mushy region extended between the interface and fully fluid metal. The word "fluid" is used rather than 100 per cent liquid, since the drainout does not distinguish between these.

Photographs of typical bars from these experiments are presented in Fig. 6. These data may be summarized, as indicated in Table 2.

It is evident that only two of the four alloys listed as Class 1 show smooth front freezing as compared with mushy freezing. In the 89-1-10 aluminum bronze and the manganese bronze there was only 0.3 in. of dendritic material ahead of the completely solid material. By contrast the other alloys in both Class 1 and Class 2 showed much wider mushy regions.

Microstructures

To corroborate the density and leakage data, microspecimens were examined from the important centerline locations. In addition, a survey of microstructure was made from cope to drag surface at the important

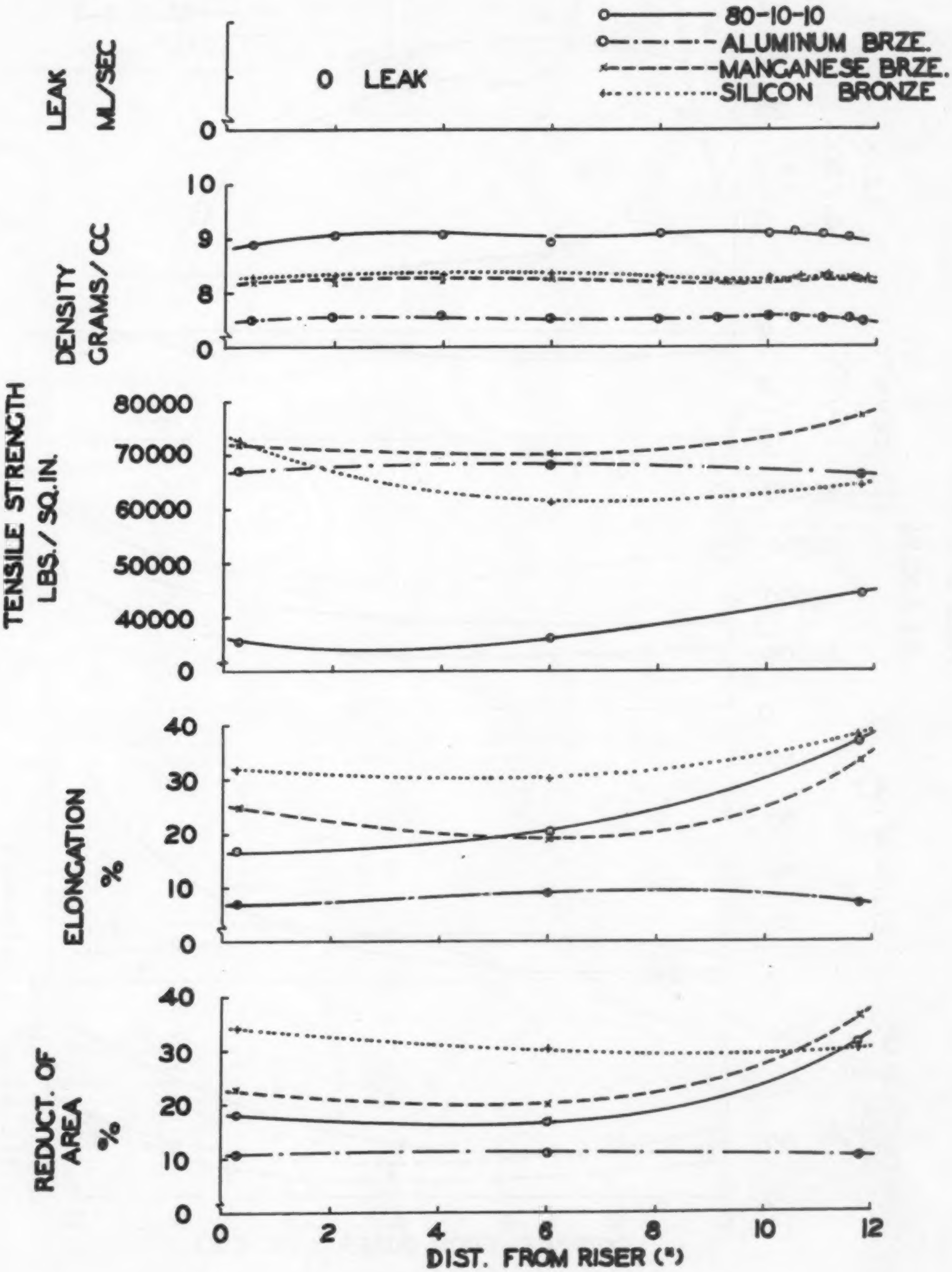


Fig. 3a — Mechanical properties of the non-leaking alloys group.

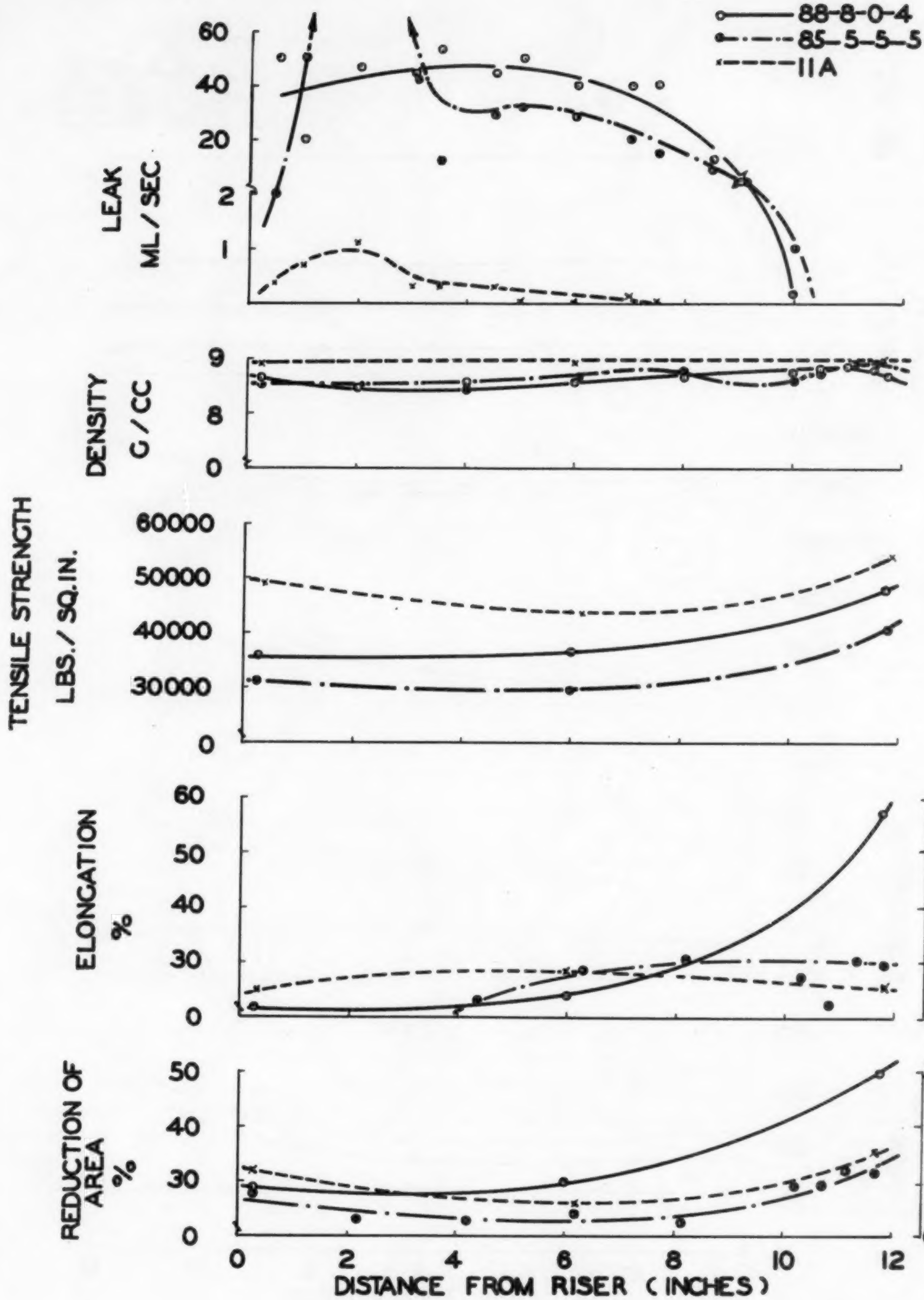
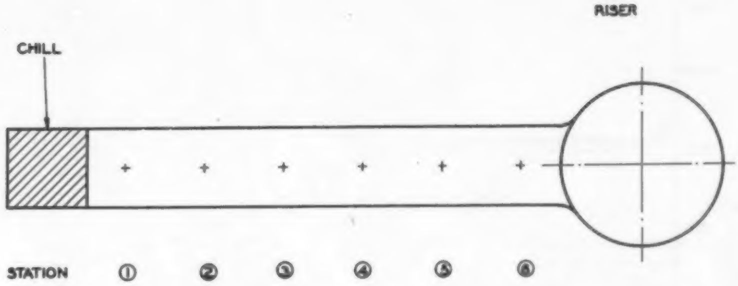


Fig. 3b — Mechanical properties of the alloy group exhibiting leakage.

Fig. 4a — Standard test bar showing thermocouple station arrangement.



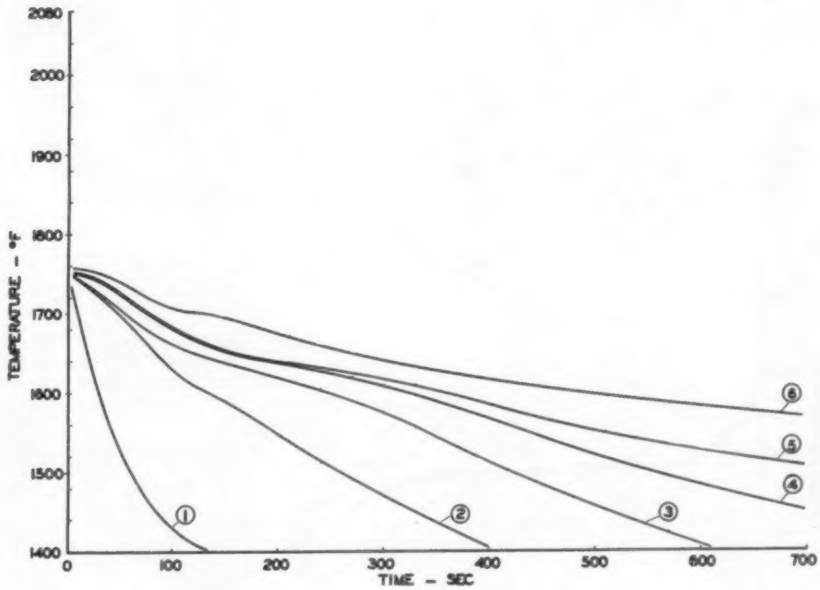


Fig. 4b — Time-temperature cooling curves for 80-10-10 (3A) alloy. Induction furnace, P-Cu deoxidation, 1905 F pouring temperature, dry sand, end chill.

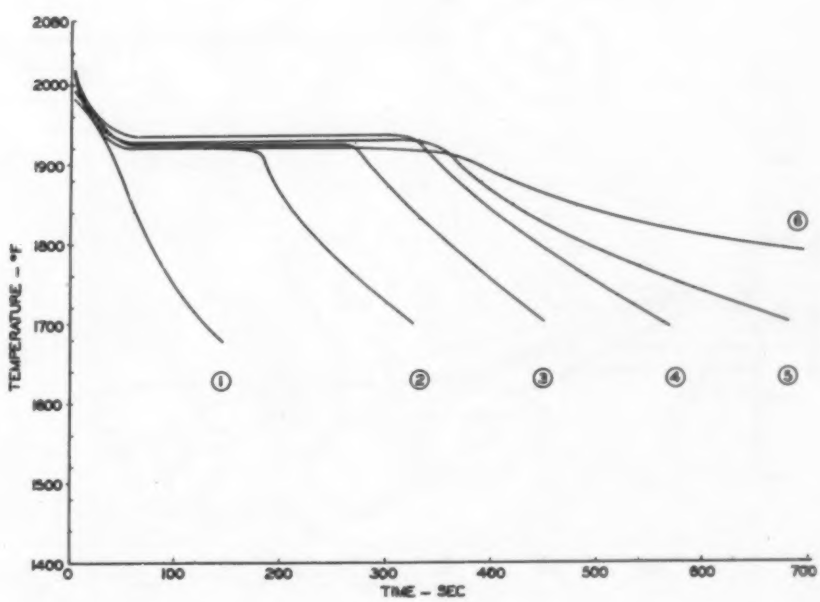


Fig. 4c — Time-temperature cooling curves for aluminum bronze (9B). Induction furnace, no. 77 alloy deoxidation, 2115 F pouring temperature, dry sand, end chill.

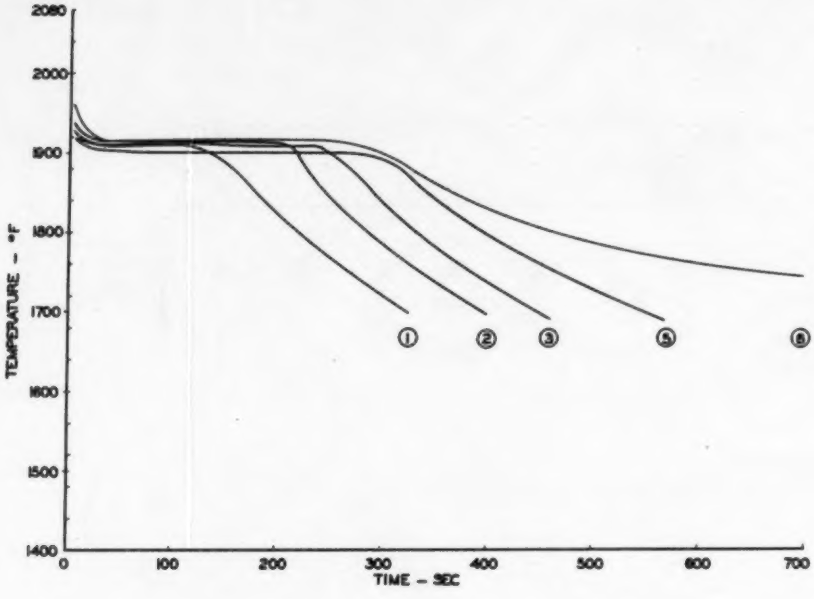


Fig. 4d — Time-temperature cooling curves for aluminum bronze (9B). Induction furnace, no. 77 alloy deoxidation, 2115 F pouring temperature, dry sand, no chill.

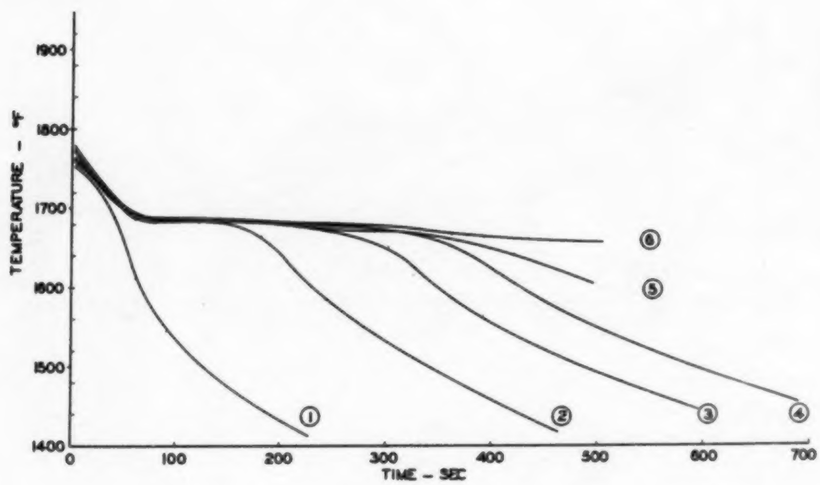


Fig. 4e — Time-temperature cooling curves for manganese bronze (8A). Induction furnace, no deoxidation, 1890 F pouring temperature, dry sand, end chill.

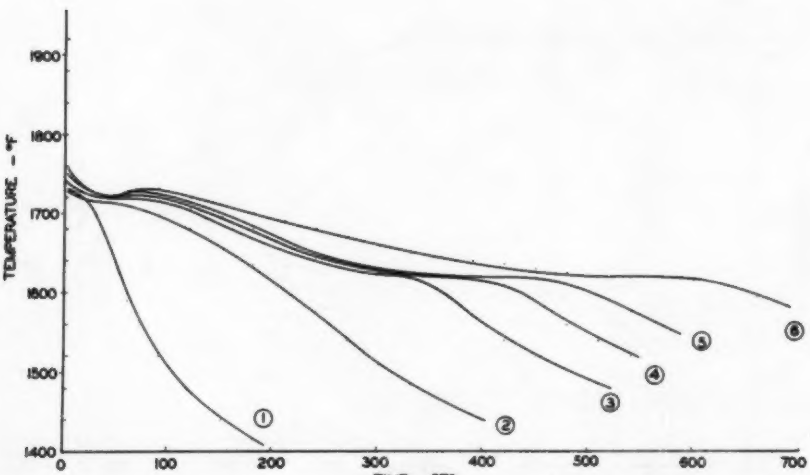


Fig. 4f — Time-temperature cooling curves for silicon bronze (13A). Induction furnace, no deoxidation, 1885 F pouring temperature, dry sand, end chill.

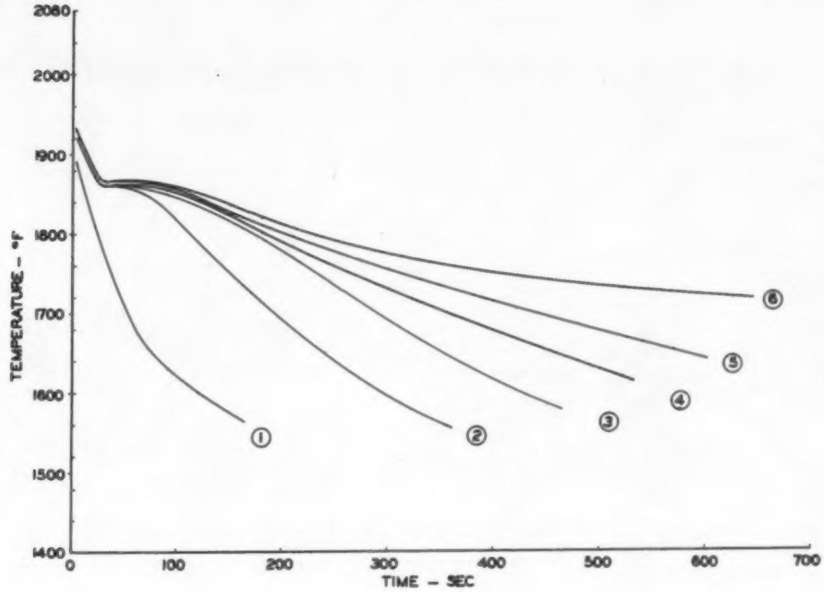
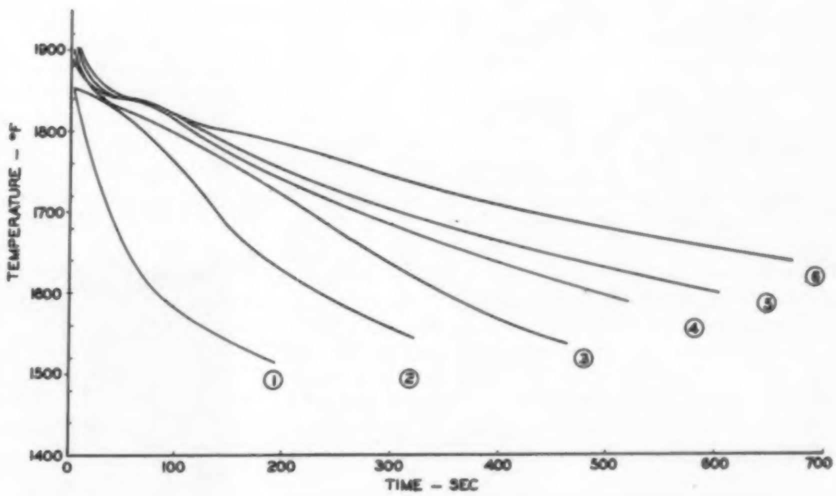


Fig. 4g — Time-temperature cooling curves for 88-8-0-4 (1B). Induction furnace, P-Cu deoxidation, 2050 F pouring temperature, dry sand, end chill.

Fig. 4h — Time-temperature cooling curves for 85-5-5-5 (4A). Gas furnace, P-Cu deoxidation, 2025 F pouring temperature, dry sand, end chill.



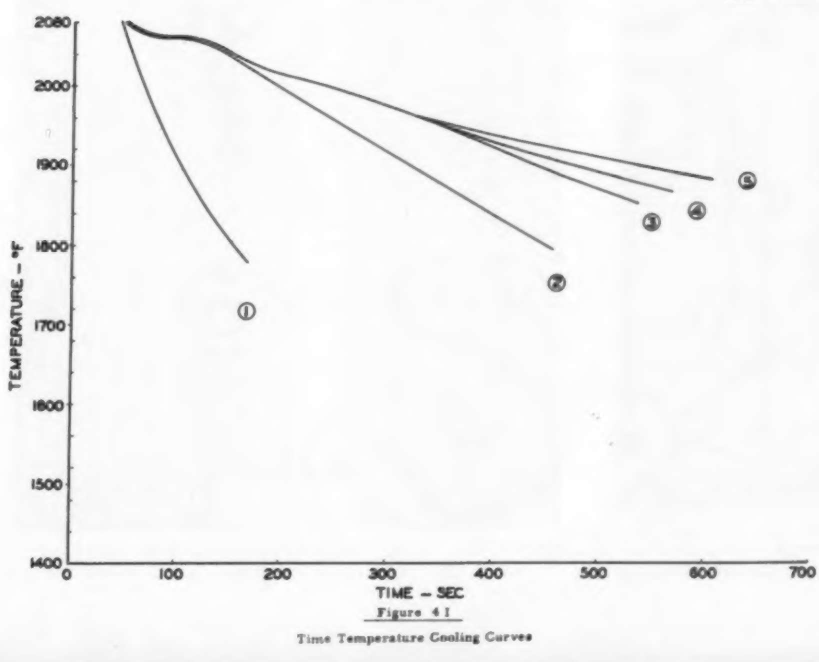


Figure 4 I

Time Temperature Cooling Curves

Fig. 4i — Time-temperature cooling curves for nickel silver (11A). Induction furnace, no. 66 alloy plus Mg sticks deoxidation, 2300 F pouring temperature, dry sand, end chill.

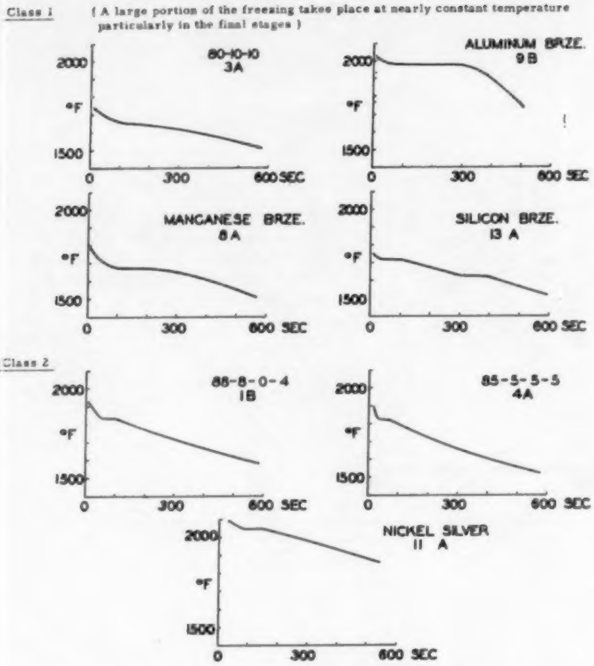


Fig. 5 — Schematic cooling curves for alloys showing differences in final solidification characteristics. Data from station 4, 5 in. from riser. A large portion of the freezing takes place at nearly constant temperature, particularly in the final stages.

locations, i.e., next to the riser (11¼-in. from the chill), at the center of the bar (6¼-in. from the chill) and near the end chill (¾-in. from the chill face).

These results may be summarized in Table 3 and Fig. 7. It is evident that the Class 1 alloys, 3 B – 80-10-10, 8 A – Mn bronze, 9 B – Al bronze and 13 A – Si brass are free from microshrinkage in the specimens examined at 100 diameters.

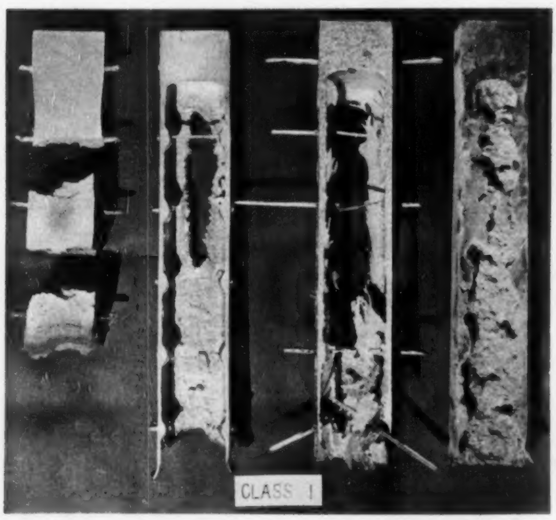


Fig. 6a — Class one drainout results. *Left to right* — 80-10-10 (3A), 30 sec; aluminum bronze (9B), 60 sec; manganese bronze (8A), 60 sec; silicon bronze (13A), 60 sec.

TABLE 2 — DRAINOUT CHARACTERISTICS OF COPPER-BASE ALLOYS

Alloy	3 A 80-10-10	1 B 88-8-0-4	4 A 85-5-5-5	8 A Mn Bronze	9 B 89-1-10	11 A Ni Silver	13 A Si Brass
Time of Drainout (sec. after pouring)	30	30	30	60	60	120	60
Distance from chill to point of 100% drainout	1.6	1.75	2.5	1.4	1.4	6.9	
Distance from chill to point of 100% solid	≪1	<1.0	<1	1.1	1.1	1.0	4.0
Mushy zone	≫0.6	≫0.75	>1.5	0.3	0.3	5.9	2.4

DISCUSSION

Before taking up the principal points of the discussion it may be generally helpful to recall some of the predictions made at the beginning of this investigation. This is done not to discredit the predictions, which represent present metallurgical thinking, but to guide the reader more quickly to the interesting anomalies in the data.

At the beginning of this year's work, it had been

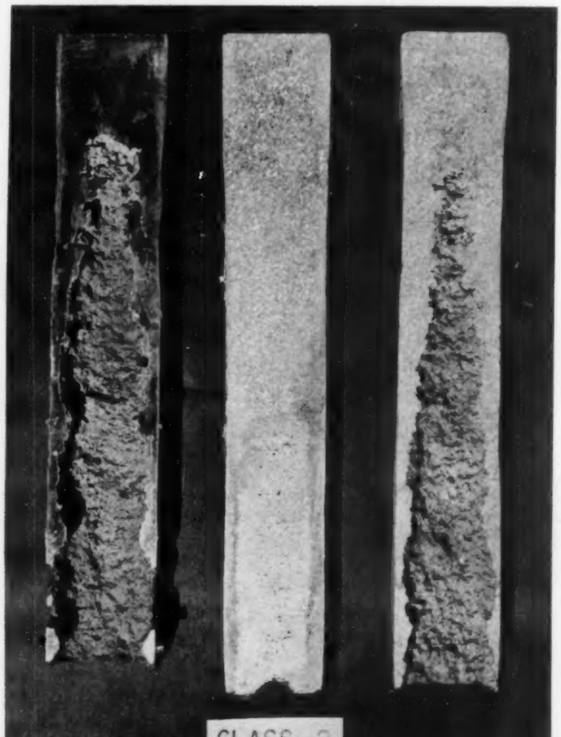


Fig. 6b — Class 2 drainout results. *Left to right* — 88-8-0-4 (1B), 30 sec; nickel silver (11A), 120 sec; 85-5-5-5 (4A), 30 sec.

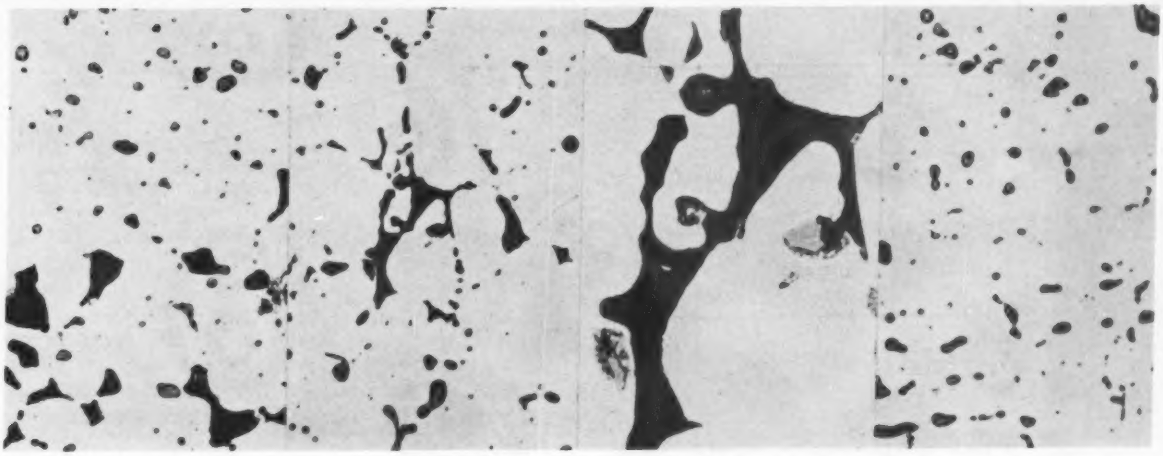


Fig. 7 — Specimen 3007. Microshrinkage in 85-5-5-5 bar at ½-in. from riser and at designated location. *Left to right* — ¼-in. from cope surface (shrink), 100 ×; at center of bar (shrink), 100 ×; center of bar (shrink), 500 ×; ¼-in. above drag surface (no shrink), 100 ×.

established that a certain thermal gradient (60 F/in.) at the solidus was required to insure soundness in 85-5-5-5 alloy castings. It seemed natural then to investigate other copper-base alloys using the same test bar and determine a simple number, the thermal gradient, required to produce sound castings in these other analyses. A representative group was selected with different liquidus-solidus intervals ranging from 15 to 302 degrees. It was generally predicted that the alloys with a short interval would require a smaller gradient while others, such as 80-10-10 and silicon brass with longer intervals, would probably give unsound bars in all cases.

The data just presented show, on the contrary, that the two alloys with relatively long freezing ranges produced bars as sound as those with the shortest freezing ranges. It is evident therefore that some new thought is required.

To summarize the data in another way, there are four alloys in Class 1 which show no leakage or microshrinkage and exhibit little variation in mechanical properties at various locations in the test bar. Although the liquidus-solidus distance varies considerably in these alloys, they all have the common feature of a flat cooling curve at final solidification (assumed in the case of 80-10-10). Apparently two different mechanisms are needed to explain the soundness of the aluminum and manganese bronzes with narrow freezing ranges compared to the silicon brass and the 80-10-10 alloy.

Mechanism 1 — Soundness in Short Freezing Range Alloys

To explain the soundness of these alloys it is useful first to review briefly the role of constitutional supercooling in the morphology of solidification. It is necessary to discuss the freezing of pure metals first and then of alloys.

To summarize the conditions prevailing during the solidification of a pure metal, let us now review what occurs when a metal of freezing temperature T_E freezes when poured into a mold. If poured rapidly there is no appreciable gradient at time = t_o (Fig. 8).

TABLE 3 — MICROSHRINKAGE AT DIFFERENT LOCATIONS IN TEST BAR

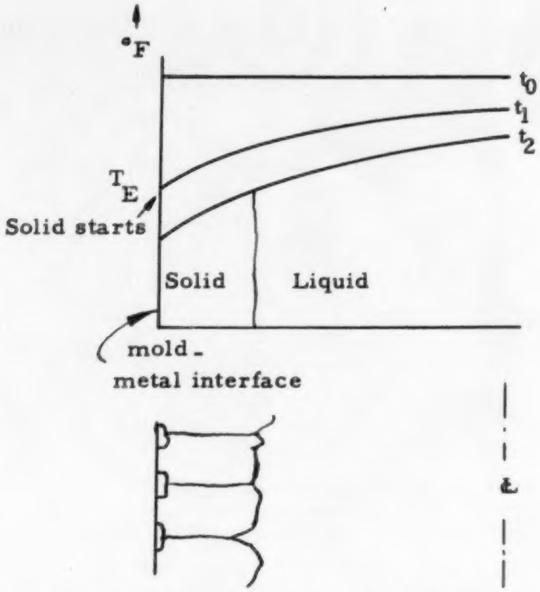
Alloy[1]		3 A 80-10-10	1 B 88-8-0-4	4 A 85-5-5-5	8 A Mn Bronze	9 B 89-1-10	13 A Si Brass
	C	O	X	X	O	O	O
riser end	C.L.	O	X	X	O	O	O
	D	O	O	O	O	O	O
	C	O	O	O	O	O	O
mid-section	C.L.	O	X	X	O	O	O
	D	O	O	O	O	O	O
	C	O	O	O	O	O	O
chill end	C.L.	O	O	O	O	O	O
	D	O	O	O	O	O	O

1. C = ¼-in. beneath cope surface.
C.L. = at centerline.
D = ¼-in. above drag surface.
X = Microshrinkage present.
O = No microshrinkage present.

Due to the heat transfer at the interface, a gradient develops in the metal. The interface temperature falls slightly below T_E and random crystallization begins at t_1 at the interface (heterogeneous nucleation, Fig. 8a). To digress a moment, it should be recalled here that there is a direction of preferred growth in a crystal. A familiar example is the growth of ice crystals on a window pane.

Returning now to the metal, those nuclei which happen to be formed with the preferred growth direction perpendicular to the interface grow more rapidly than crystals of other orientations. This leads to the growth of columnar grains to the center of the ingot. The final structure therefore consists of a thin layer of randomly oriented grains at the mold surface and columnar grains extending to the centerline. There are no dendrites or randomly oriented grains at the center of the ingot.

Nucleation and growth in alloys. The three principal differences between solidification of pure metals and their alloys are:



Figs. 8a and 8b — Solidification of a pure metal.

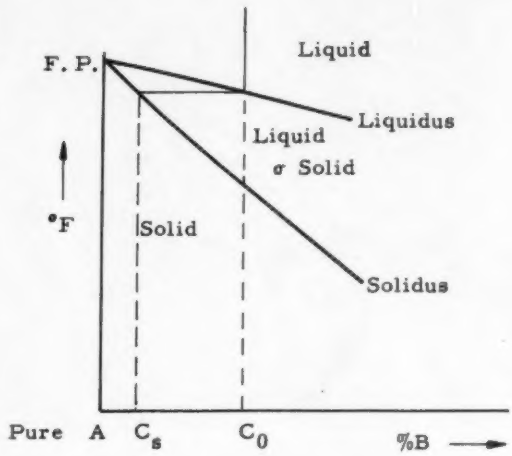


Figure 9

Schematic Phase Diagram

Fig. 9 — Schematic phase diagram.

1. Usually freezing occurs over a temperature range.
2. The composition of the solid which separates first is different from that of the liquid.
3. There may be more than one solid phase crystallizing from the liquid.

Solid solution alloys. If we dissolve metal *B* in liquid metal *A* to form a liquid alloy, we can describe the crystallization by a phase diagram, as shown in Fig. 8b. In most cases the freezing point of the pure metal is depressed, as shown by the liquidus line. In addition the alloy, of composition C_o for example, does not freeze at a single temperature but instead freezes over a temperature range.

Another important effect is that as the metal solidifies the composition of the solid is not the same as that of the parent liquid, but is richer in metal *A*. We shall discuss now how these effects lead to a solidification pattern different from those described for the pure metal.

If we begin with a homogeneous melt of composition C_o, the first crystals to precipitate are of analysis C_s (Fig. 9). If solidification is fairly rapid and no diffusion occurs, the liquid at the interface becomes richer in the solute *B* than the liquid away from the interface. The variation of per cent *B* with distance is shown in Fig. 10.

Freezing mechanism modification. Let us see how these effects modify the freezing mechanism compared with that of a pure metal.

Assume the mold is filled rapidly, as in the previous case, giving no temperature gradient at the start where time $t = 0$ (Fig. 11). Consider the liquidus temperature as T_E. As previously mentioned, we establish a thermal gradient and supercool somewhat before crystallization begins at time t_1. Consider the situation at t_2 (after appreciable solid has separated)—a temperature gradient similar to that of the pure metal is assumed.

The difference between this situation and that of the pure metal is that the liquidus temperature of the remaining liquid now varies with distance from the interface, as shown by the dashed line. Near

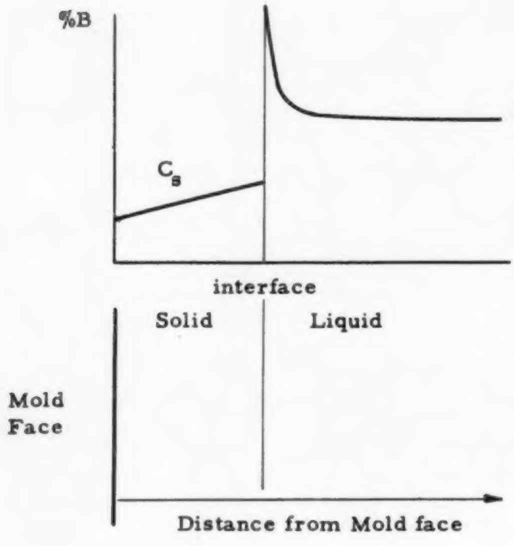


Fig. 10 — Variation of per cent B with distance.

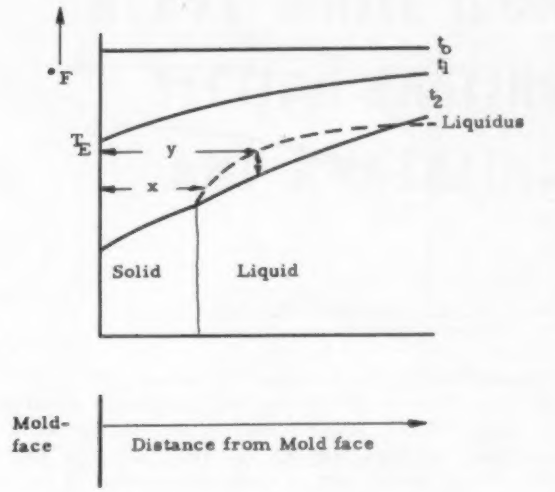


Fig. 11 — Temperature conditions during constitutional supercooling. Solid lines show actual temperature in the mold at t_0, t_1 and t_2.

the interface, due to buildup of component *B* in the liquid, the freezing temperature is considerably lower than T_E. Well away from the interface the equilibrium freezing temperature is still T_E, assuming no diffusion.

Notice now that a region of liquid at point *x* has a higher freezing point than the liquid at the interface. It is true that the actual metal temperature at *x* is higher than at the interface. However, the difference in the liquidus temperature between metal at *x* and metal at the interface is greater than the difference between their actual metal temperatures. Therefore, the metal at *x* is said to be constitutionally supercooled. The effects of this supercooling upon the crystallization are of three types, depending upon the degree of supercooling:

1) If there is only minor supercooling, certain preferred regions of the interface will protrude into the undercooled region and, once started, will grow more rapidly than neighboring regions, Fig. 12. This will happen both because of the greater driving force for freezing in the supercooled region and because these spikes will reject solute at their sides, delaying freezing of the side regions. These spikes result in formation of a regular honeycomb structure.
2) If supercooling is greater, the spikes tend to form side arms resulting in a dendritic structure, Fig. 13.
3) Finally, in the case of maximum supercooling, the driving force, $T_{liquidus}$-T_{actual}, which is a maximum at distance *y*, (Fig. 11) can lead to independent crystallization. In this way randomly oriented (equiaxed) grains are encountered. A case of this type is shown in Fig. 14. It should be mentioned that the relative solubility of the solute is shown by the factor *k* where:

$$k = \frac{C_s}{C_o}$$

k can be 0.5, as shown in the sketch to 10^{-2}. When *k* is low, and the thermal gradient low, even the metal at the center of the casting can be undercooled.

It should be noted on the other hand that the greater the thermal gradient, the greater the possibility for columnar growth. This avoids random crystallization ahead of the freezing interface and facilitates metal flow for feeding of solidification shrinkage. In other words, the greater the thermal gradient, as in chilled castings, the simpler the feeding problem.

Mass feeding. There is one other effect called mass feeding which should be mentioned for completeness. In a section in which equiaxed crystals are nucleated randomly, the tendency of these crystals is to sink because of the greater density of the solid. This effect results in less porosity at the bottom portion of a section than in the upper part.

From this discussion it is evident that the longer the liquidus solidus distance and the greater the distribution coefficient *K*, the more likely is the formation of random equiaxed crystals away from the freezing front. This is particularly noticeable in the Class 2 alloys such as 85-5-5-5 (Fig. 6b). By con-

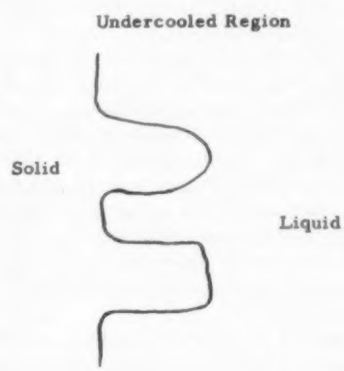


Fig. 12 — Minor supercooling effect.

Fig. 13 — Spike formation due to progressively severe supercooling conditions.

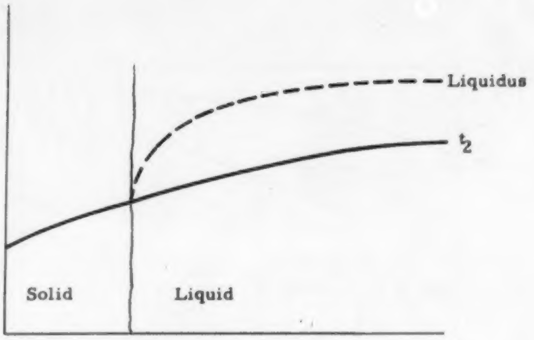


Fig. 14 — Liquidus and actual temperature variations as a function of distance from the mold face during maximum supercooling conditions.

trast, the shorter liquidus-solidus distance and higher *K* value for the aluminum and manganese bronzes promote smooth front solidification, as shown in Fig. 6a. It is even possible to remove the end chill and obtain sound bars of aluminum bronze. This is because the sand cast end surface provides enough end cooling to develop directional solidification.

Mechanism 2

It is now necessary to consider another explanation for the soundness of the 80-10-10 and the silicon bronze which are admittedly long freezing range alloys. It is proposed tentatively that although the primary crystallization in both these materials proceeds by formation of a network of copper rich α crystals, the final stages of solidification are similar to the narrow range liquids just discussed.

Silicon bronze. In the case of the silicon bronze, the cooling curves are quite different from the alloys which exhibit shrinkage, such as 85-5-5-5. The marked difference is in the long flat portion of the curve at the period of final solidification. This indicates that a substantial amount of liquid is present. The cooling curves at the different stations drop off from this final plateau just as those of the narrow range materials drop off from the single plateau. This signifies there is an orderly movement of the end of freezing wave down the bar from the chill to the riser, and that there is no constitutional supercooling.

It is assumed, therefore, that after the original α network has forme l there is adequate space and time for orderly motion of the remaining liquid toward the chilled end of the bar, as required to avoid shrinkage.

The microstructure of the silicon brass shows clearly the primary α crystals surrounded by the lower melting point material. It is proposed that the same mechanism leads to a sound structure in 80-10-10 although thermocouple data were not obtained for the low temperature range.

Copper-lead. The copper-lead phase diagram shows slight solubility of lead in the solid copper phase, and this is probably not increased appreciably by the tin. Therefore, at least 10 per cent of the total alloy (lead) is liquid to low temperatures. Data are not available for the partition of the tin between the solid copper rich α phase and the liquid lead phase. However, since the maximum solubility of the tin in the α is only 10 per cent, and unlimited in liquid lead, it is possible that at least half of the tin should be dissolved in the liquid lead phase. In other words the bar may contain 15 per cent liquid to rather low temperatures.

For example, the freezing of a 66 per cent lead 34 per cent tin alloy (following the proportion of 10 Pb 5 Sn) would result in the freezing of an α Pb phase from 600 F to 361 F and of the Pb-Sn eutectic at 361 F. Under the conditions assumed, half of this lead alloy would crystallize at the eutectic. Probably the tin content of the lead alloy would be greater, and therefore the eutectic amount would be greater. To determine if the lead content alone was responsible for the better density of the 80-10-10, a 5 per cent lead addition was made to the 85-5-5-5 alloy giving approximately 80-5-10-5. This alloy showed some improvement over the 85-5-5-5. Further critical experiments are obviously indicated.

PRACTICAL APPLICATIONS

While this paper constitutes a progress report, and further testing is required, the following applications may be suggested:

When risering is possible, aluminum bronze and manganese bronze provide maximum strength and pressure tightness. From present indications silicon bronze and 80-10-10 also produce sound castings. The thermal gradients required to produce sound castings in these alloys are less than for 85-5-5-5. In intricate castings where risering is difficult, the higher tin-lead ratios may be of value in that selected regions may be made pressure tight by chilling.

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HEAVY WHITE IRON SECTION CASTING AND ANNEALING

Progress Report
Malleable Division Research
Sponsored by
AFS Training & Research Institute

by R. W. Heine, T. W. Mueller and J. W. Widmeyer

ABSTRACT

This is one of the research project reports on casting heavy sections in white iron and then annealing them to malleable iron. Chemical analyses of iron and additions to the melt for casting heavy sections as white iron with no mottle spots on a fractured surface, and time-temperature requirements for annealing the heavy sections to produce malleablized iron were studied.

A drastic decrease in the number of graphite nodules developed during annealing as the as-cast section increased. When Bi, Te or Ce are used for prevention of mottling, there is no improvement in the number of nodules during annealing. Those factors which are known to increase nodule number in lighter sections have less effect in heavy sections. Increasing the silicon percentage produces an increase in nodule number.

Cerium is revealed as another element capable of producing white fractures at C and Si percentages where mottle or gray fractures would normally occur.

INTRODUCTION

The third annual report of a research project aimed at casting heavy sections in white iron and then annealing them to malleable iron is presented herewith. The project is sponsored by the AFS Training & Research Institute under the direction of the AFS Malleable Division at the University of Wisconsin. Subjects selected for study were:

1. Chemical analyses of iron and additions to the melt for casting heavy sections as white iron so that no mottle spots appear on a fractured surface.
2. Temperature-time requirements for annealing the heavy sections to produce a malleablized iron.

References 1, 2 and 3 present the results of work completed earlier in this project, comprising the first two annual progress reports.

CASTING WHITE

Figure 1, from a reference[1] shows the per cent carbon and per cent silicon limits for white vs. mottled fractures under various conditions of melting and metal additions for a 4 x 4 x 8 in. block casting risered on one end. Details of melting practice involving 100 lb induction furnace heats are described in references,[1,2] as are the methods of making additions. Figure 1 shows the base composition curve for melting under a dry atmosphere, and also for melting under an atmosphere containing 12 grains of moisture/cu ft of gas. Also shown on Fig. 1 are composition limit curves for additions of Bi and Te to the melt. Compositions above the respective curves are mottled, and below the curves are white.

Composition limit curves for a 1⅞-in. D Bar, a 2 x 2 x 8 in. bar, and 3 x 3 x 8 in. bar are shown in Fig. 2. The curve for the 1⅞-in. D bar was also presented.[1] A 2 x 2 x 8 in. D bar should have about the same freezing time as a 1⅞-in. D bar. Therefore, the carbon and silicon limits for mottling are expected to be about the same. Heats were made to compare mottling in these two bars and also the 3 x 3 x 8 in. bar with the earlier work for the 4 x 4 x 8 in. bar. Chemical analyses and fracture data for these heats are reported in Table 1.

The points are plotted on Fig. 2, and show that the 2 x 2 x 8 in. D bars, and even the 3 x 3 x 8 in. D bars, have the same C and Si percentage limits for mottling. This appears to be true for the heats with no additions and with additions of Bi and Te. As in the previous work, additions were made to the melt

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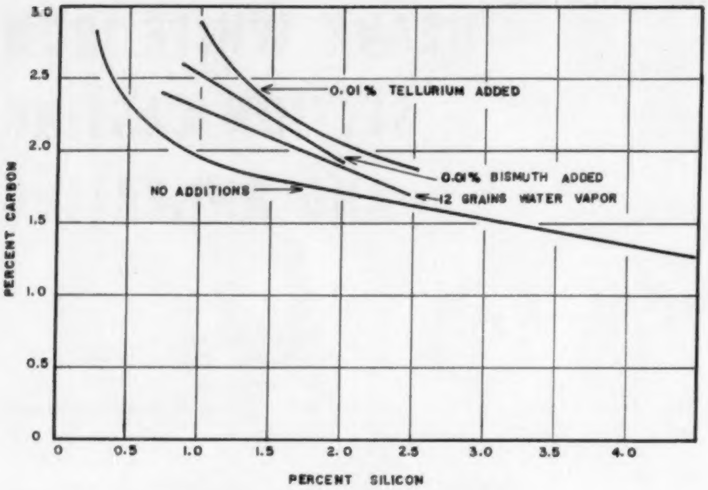

Fig. 1 — Curves showing the limiting carbon and silicon percentages for white iron fractures in a 4 x 4 x 8 in. casting risered on one end, from a reference.[1] The base curve is for irons with no additions melted under standard conditions, while the higher curves are for the addition of 12 grains water/cu ft furnace atmosphere, 0.01 per cent Bi and 0.01 per cent Te, respectively.

by plunging. The Bi or Te additions were wrapped in low carbon steel sheet. The package was wired to a rod for simultaneously plunging into the melt and storing.

A variety of additions were used alone and in combination. Aluminum, boron, zinc and 12 grains water vapor/cu ft* of furnace gases were used as well as Bi and Te. Percentage added varied from 0.003 per cent B, 0.016 to 0.02 per cent Al, 0.01 per cent Zn and 0.01 per cent Bi to 0.01 to 0.20 per cent Te. Table 1 gives the kind and size of additions for each heat. No different results were obtained than have already been described in past reports.[1,3]

CASTING WHITE WITH CERIUM ADDITIONS

In a reference,[1] the authors hypothesized that certain other elements should have an effect similar to that of Bi and Te in raising the C and Si percentages for mottling. Cerium was suggested as one of these elements, but was found to be ineffective in the range of 0.01 to 0.11 per cent Ce added. This was thought to be due to a side reaction of Ce with S, resulting in the formation of cerium sulfide. If the sulfur content of the iron was lowered, it was thought that cerium would then be effective. To ascertain the truth, heats M59, M60, M63, M78, M79, M80 and M83 were prepared with and without desulfurization.

By means of basic slag, sulfur content was lowered from the range of 0.05 to 0.09 per cent S to a range of 0.015 to 0.025 per cent. Desulfurization was performed with a synthetic slag consisting of lime, calcium carbide, fluorspar, sodium carbonate, magnesia and silica with a basicity ratio of 2·3. The slag materials were placed on the cold metal charge, and remained on the metal until a temperature of 2750-2800 F was reached.

Cerium in amounts of 0.11 to 0.70 per cent was added to the iron by plunging it into the iron at 2750 F. Under these conditions, cerium was found to

*At a flow rate of 0.78 cfm.

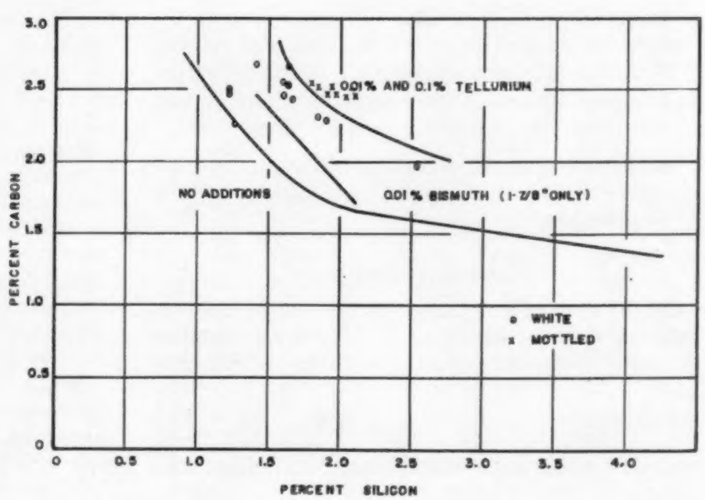

Fig. 2 — Curves showing the limited carbon and silicon percentages for white iron fractures in a 1⅞-in. D bar, a 2 x 2 x 8 in. bar and a 3 x 3 x 8 in. bar risered on both ends. The lower curve is for irons with no additions melted under standard conditions, while the higher curves are for additions of 0.01 per cent Bi and 0.01 per cent Te, respectively.

TABLE 1 — BASE COMPOSITIONS AND ADDITIONS

Heat No.	Base Composition, %			Addition, %	Casting Size — Fracture, in.				
	C	Si	P, est		1 3/8	1 7/8	2 x 2 x 8	3 x 3 x 8	4 x 4 x 8
N 19	2.56*	1.17*	0.102			M	HM	G	
N 21	2.51*	1.14*	0.102				LM	LM	
N 54	2.06	1.01	0.090				W	W	
N 55	1.92*	1.08*	0.090				W	W	
N 58	2.06	1.15	0.090				W	W	
N 59	2.06	1.25	0.090				W	W	
M 1	2.18*	1.04*	0.088				W	W	
M 3	2.34	0.95	0.096				W	W	
M 4	2.32*	1.12*	0.096				W	W	
M 6	2.28*	1.18*	0.096				W	W	
M 8	2.36*	1.28*	0.096				LM	LM	
M 14	2.36	1.28	0.096				LM	LM	
N 22	2.44*	1.15*	0.102	0.01 Bi		W	W	W	
N 23	2.48*	1.24*	0.077	0.01 Bi			W	W	
N 24	2.28	1.25	0.077	0.01 Bi			W	W	
N 25	2.28	1.25	0.077	0.01 Bi			W	W	
N 26	2.48*	1.23*	0.077	0.01 Bi		W	W	W	
N 28	2.51*	1.24*	0.102	0.01 Te			W	W	
N 29	2.48*	1.24*	0.102	0.01 Te			W	W	
N 30	2.28	1.25	0.077	0.01 Te			W	W	
N 31	2.11	1.50	0.088	0.01 Te					W
N 34	2.11	1.50	0.088	0.01 Te					W
M 2	2.34*	1.85*	0.096	0.01 Te			W	W	
M 5	2.48*	1.81*	0.116	0.1 Te			W	W	
M 7	2.44*	1.85*	0.116	0.1 Te			W	W	
M 9	2.54*	2.02*	0.116	0.1 Te			LM	LM	
M 10	2.50	2.00	0.116	0.01 Te			HM	G	
M 11	2.50	2.00	0.116	0.2 Te			W	LM	
M 12	2.50	1.90	0.116	0.2 Te			W	LM	
M 13	2.50	2.00	0.116	0.01 Te			LM	HM	
M 16	2.51	1.60	0.090	0.01 Te			W	W	
M 17	2.51	1.60	0.090	0.1 Te			W	W	
M 50	2.68	1.40	0.096	0.01 Te			W	W	
M 51	2.52	1.80	0.090	0.01 Te			LM	M	
M 53	2.52	1.75	0.090	0.01 Te			M	M	
M 54	2.37	1.90	0.089	0.01 Te			M	M	
M 55	2.52	1.60	0.090	0.01 Te			W	LM	
M 56	2.41	1.60	0.091	0.01 Te			W	W	
M 57	2.26	1.90	0.089	0.01 Te			W	W	
N 36	2.36*	1.20*	0.125	0.02 Al; 0.01 Bi; 6 gr H_2O/ft^3			W	W	
N 41	2.32*	1.25*	0.125	0.01 Te; 0.003 B; 8 gr H_2O/ft^3			W	W	
N 42	2.40*	1.23*	0.125	0.01 Te; 0.003 B; 8 gr H_2O/ft^3			W	W	
N 43	2.44*	1.39*	0.125*	0.01 Te; 0.003 B; 8 gr H_2O/ft^3			W	W	
N 44	2.52	1.45	0.113	0.01 Te; 0.003 B; 8 gr H_2O/ft^3			G	G	
N 45	2.50*	1.40*	0.126*	0.01 Te; 0.003 B; 8 gr H_2O/ft^3			W	W	
N 46	2.50*	1.39*	0.113*	0.01 Te; 0.003 B; 8 gr H_2O/ft^3			W	W	
N 47	2.42*	1.13*	0.090*	0.01 Te; 0.003 B; 8 gr H_2O/ft^3			W	W	
N 48	2.46*	1.35*	0.090*	0.01 Te; 0.003 B; 8 gr H_2O/ft^3			W	W	
N 49	2.46*	1.21*	0.080*	0.01 Te; 0.003 B; 8 gr H_2O/ft^3			W	W	
N 50	2.42*	1.39*	0.073*	0.01 Te; 0.003 B; 8 gr H_2O/ft^3			W	W	
N 51	2.38*	1.20*	0.078*	0.01 Te; 0.003 B; 8 gr H_2O/ft^3					W
N 53	2.42*	1.40*	0.086*	0.01 Te; 0.003 B; 8 gr H_2O/ft^3					W
N 14	2.10	1.40	0.090	0.02 Al; 0.01 Zn	Run out	M			G
N 15	2.36*	1.58*	0.066	0.01 Al; 0.01 Bi	W	W			W
N 16	2.02	1.50	0.090	0.004 Te; 0.02 Al	W	W			LM
N 17	2.34*	1.55*	0.066	0.02 Al; 0.01 Bi	W	W			W
N 18	2.10	1.40	0.089	0.02 Al; 0.01 Zn	LM	LM			G
N 32	2.44*	1.23*	0.078	0.02 Al; 0.01 Te			W	W	
N 33	2.43*	1.23*	0.080	0.02 Al; 0.01 Bi			Thermal data		
N 35	2.38*	1.25*	0.080	0.02 Al; 0.01 Te			W	W	
N 37	2.38*	1.40*	0.066	0.02 Al; 0.01 Te			W	W	
N 38	2.44*	1.38*	0.073	0.02 Al; 0.01 Bi			W	W	
N 39	2.44*	1.29*	0.119*	0.02 Al; 0.01 Te; 0.003 B			W	W	
N 40	2.42*	1.18*	0.120*	0.01 Te; 0.003 B			W	W	
N 60	2.19	1.60	0.089	0.01 Bi; 0.01 Al					W
N 61	2.19	1.60	0.089	0.01 Bi; 0.02 Al					W
N 62	2.19	1.60	0.089	0.01 Bi; 0.03 Al					W
M 61	2.54*	1.52*	0.090	0.01 Bi; 0.01 Te			LM	M	
M 62	2.26	1.90	0.088	0.01 Bi; 0.01 Te			M	HM	
M 63	2.36*	1.50*	0.093	0.25 Ce; Basic slag			W	W	
M 64	2.26	1.90	0.088	0.01 Te; 0.01 B; 0.01 Al			LM	M	
M 65	2.41	1.60	0.093	0.01 Te; 0.01 B; 0.01 Al			LM	LM	

(continued on next page)

TABLE 1 — BASE COMPOSITIONS AND ADDITIONS — *continued*

Heat No.	Base Composition, %			Addition, %	Casting Size — Fracture, in.				
	C	Si	P, est		1⅜	1⅞	2 x 2 x 8	3 x 3 x 8	4 x 4 x 8
M 59	2.52	2.25	0.096	0.13 Ce (Desulfurized 0.015S)			LM	LM	
M 60	2.52	2.25	0.096	0.26 Ce (Desulfurized 0.015S)			LM	LM	
M 63	2.36*	1.50*	0.093	0.25 Ce (Desulfurized 0.015S)			W	LM	
M 78	2.43	2.25	0.120	0.18 Ce		G			
M 79	2.60*	2.25	0.120	0.44 Ce		W			
M 80	2.54*	2.25	0.120	0.60 Ce		W			
M 83	2.50	2.25	0.120	0.31 Ce		G			

* — Commercial chemical analysis.
W — White.
M — Mottled.
LM — Lightly mottled.
HM — Heavily mottled.
G — Gray.

produce a white fracture when the amount added exceeded 0.35 to 0.40 per cent in undesulfurized heats M79 and M80. The latter heats were made at a nominal analysis of 2.25 per cent Si and 2.50 per cent C. This carbon and silicon level is above the mottling curves for tellurium in Fig. 2.

A white fracture was produced when the added cerium exceeded about 0.25 to 0.30 per cent in desulfurized heats M60 and 63. Many additional heats not reported in Table 1 have been made using cerium additions. These heats all show that cerium in amounts of 0.35 to 0.40 per cent produces a white fracture in 1⅞-in. D bar, without prior desulfurization of the iron. This is accomplished over the composition range of 1.50 to 2.25 per cent Si and 2.50 per cent C. Cerium may then be regarded as an element having an effect on mottling similar to that of Bi and Te but requiring a larger addition.

TABLE 2 — FREEZING TIME OF WHITE IRON POURED IN GREEN SAND, 2700 F POURING TEMPERATURE

Casting Size, in.	Freezing Time, min	Comments
1 15/16 x 1 14/16 x 8	12.0	Riser on each end of bar
2 15/16 x 2 13/16 x 8	23.0	Riser on each end of bar
4 x 4 x 8	39.0	Riser on each end of bar

FREEZING TIME OF TEST BAR CASTINGS

The freezing time of the castings in green sand molds was determined from cooling curves using platinum type thermocouples inserted into the mold cavity. The freezing time was chosen as the time from pouring the iron (at 2700 F) to the end of the eutectic freezing process. Freezing times are listed in Table 2. Freezing times could be plotted as a function of A/V ratio, or freezing time vs. section size. The latter type of plot, shown in Fig. 3 for these data, is the middle curve for bars. The present data were found to be in agreement with the data in the reference[4] on an A/V vs. freezing time basis. These data and reference[4] were then used to compute the freezing curves for plates and spheres, the upper and lower curves on Fig. 3.

Freezing time of the 3 x 3 x 8 in. bar is 23 min, while the 2 x 2 x 8 in. bar freezes is 12 min. One may ask then why the two bars show almost identical

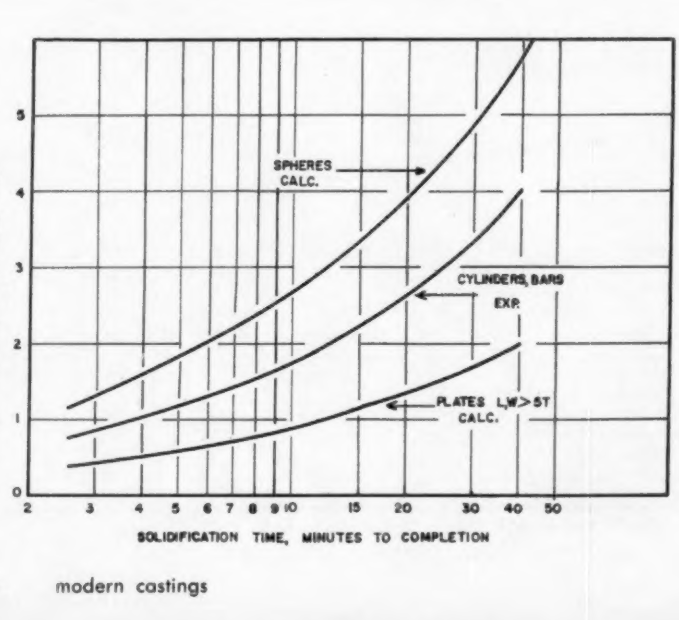

Fig. 3 — Relationship of freezing time of cast sections to section size of casting in a green sand mold. The metal is poured at 2700 F. Points on middle curve are from Table 2. Upper and lower curves are calculated.

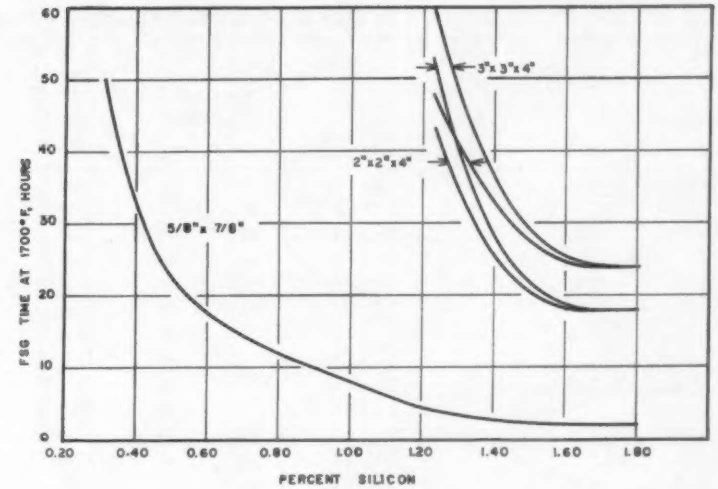

Fig. 4 — Time required for FSG at 1700 F as related to per cent silicon in the iron for 2 x 2 x 4 in. and 3 x 3 x 4 in. bars. The lower curve is the minimum time required for a 0.75 x 0.625 x 1.50 in. bar having over 3500 graphite nodules/cu mm (see text).

curves of C and Si limits for mottling in Fig. 2. In only one case heat M55, Table 1, was the 3 x 3 x 8 in. bar mottled when the smaller bar was not, with normal size Te additions. The 4 x 4 x 8 in. bar definitely has lower limits for carbon and silicon than the smaller bar. The answer to this involves the question of the temperature where mottling begins. Cooling curve and other data indicate that mottling begins at the upper temperatures in the eutectic range.

The carbon and silicon limits for mottling would be more closely related to the time to cool through the temperature range where mottling begins than it would to the time to cool through the end of the eutectic freezing temperature. The start of eutectic freezing is reached almost as soon in the 3 x 3 x 8 in. bar as in the 2 x 2 x 8 in. D bar, even though the end of eutectic freezing takes much longer in the bigger bar. This is believed to be the reason for the lack of difference in C and Si limits for mottling in the 2 x 2 x 8, 3 x 3 x 8 in. bars and 1⅞-in. D round bars.

ANNEALING HEAVY SECTIONS

The time-temperature requirements for annealing light section castings of iron treated with bismuth, tellurium and other elements were described in a reference.[3] This reference reports the work done earlier in this project on the effect of a host of addition elements on annealability. This report extends the results to heavier sections represented by the 2 x 2 x 4 in. and 3 x 3 x 4 in. test bars. Annealability tests consist of determining the hours required for first stage graphitization (FSG) at 1700 F and the cooling rate in degrees F/hr necessary for second stage graphitization (SSG). The results of these tests are reported in Table 3. The FSG time at 1700 F is summarized graphically in Fig. 4. Figure 4 shows the time required to FSG the 2 x 2 x 4 in. and 3 x 3 x 4 in. test bars at 1700 F as a band for the range of less than or more than a certain number of hours at a specified per cent silicon. For comparison, the minimum FSG time required in a ⅝ x ⅞-in. sections is shown on Fig. 4 from a reference.[3] Some of the reasons for the differences in FSG time required in different section sizes will be discussed.

NODULE NUMBER*

After studying graphitization during annealing in several heats, it soon became apparent that developing a sufficient number of graphite nodules was a major problem in heat treatment of heavy section malleable iron. For example in heats N29, N23, N40, N36 and N38, varying from 1.20 to 1.40 per cent Si, and varying in additions with 0.01 per cent Te, 0.01 per cent Bi, 0.02 per cent Al, 8 gr water vapor/cu ft and 0.003 B per cent, nodule numbers in the range of 650 to 2900 nodules/cu mm developed. This is too low for most rapid graphitization according to previous work.[3] Most rapid graphitization at SSG requires over about 3500 nodules/cu mm.

Inspection of Table 3 shows in all cases that the number was marginal or too low for FSG, and definitely too low for SSG at most rapid rates. Much effort was expended to raise nodule number. Many of the known methods of increasing nucleation were tried as:

1. *Boron.* Heats N39 to N53 had 0.003 per cent added.
2. *Aluminum.* Heats N32 to N39 had 0.02 per cent Al added.
3. *Water vapor or hydrogen.* Heats N35, N36 and N41 to N53 had 6 to 8 gr water vapor/cu ft furnace atmosphere gas.
4. *Pretreatment.* All heats were annealed with and without pretreatments of 2 hr at 600 F and 4 hr at 1200 F.
5. *Hot shakeout.* The 2 x 2 x 8 in. and 3 x 3 x 8 in. castings were shaken out 35 min after pouring, and the 4 x 4 x 8 in. castings were shaken out 45 min

*Nodule numbers are determined by the method described in reference 5.

TABLE 3 — ANNEALABILITY EXPERIMENTS

Heat No.	Si, %	P, %	Section Size, in.	FSG Treatment Time, hr Greater Than	FSG Treatment Time, hr Less Than	Temp., F	SSG Cooling Rate, F/hr Greater Than	SSG Cooling Rate, F/hr Less Than	Nodule Number For Shorter FSG Time	Nodule Number For Longer FSG Time	Comments*
N 41	1.25	0.125	2 x 2 x 4	30	36	1700			1960	2000	1
			3 x 3 x 4	40	46	1700			1660	1680	1
N 42	1.23	0.125	2 x 2 x 4	42	48	1700			2220	1980	1
			3 x 3 x 4	52	60	1700			1720	1540	1
N 43	1.39	0.125	2 x 2 x 4	30	36	1700			3220	3120	1
			3 x 3 x 4	40	48	1700			2260	2160	1
N 45	1.40	0.126	2 x 2 x 4		24	1700				3020	1
			3 x 3 x 4		34	1700				2560	1
N 46	1.39	0.113	2 x 2 x 4		56	1700	10	20	2900	2700	1
			3 x 3 x 4		56	1700	10	20	2500	2300	1
N 47	1.13	0.090	2 x 2 x 4	30	36	1700			1100	1040	1
			3 x 3 x 4	40	46	1700			760	780	1
N 48	1.35	0.090	2 x 2 x 4	24	30	1700			2600	2440	1
			3 x 3 x 4	34	40	1700			1780	1860	1
N 49	1.21	0.080	2 x 2 x 4		56	1700	10	20	1500	1600	1
			3 x 3 x 4		56	1700	10			1480	1
N 50	1.39	0.073	2 x 2 x 4		56	1700	10	20		3000	1
			3 x 3 x 4		56	1700	10	20		2200	1
N 51	1.20	0.078	4 x 4 x 4	50	56	1700			800	900	1
N 53	1.40	0.086	4 x 4 x 4	44	50	1700			1500	1680	1
M 2	1.85	0.096	2 x 2 x 4	12	24	1700			662	1312	2
			3 x 3 x 4	12	24	1700			1750	2250	2
M 7	1.85	0.116	2 x 2 x 4		12	1700				5000	2
			3 x 3 x 4	12	24	1700			2662	2920	2
M 12	1.90	0.116	2 x 2 x 4	12	24	1700			1420	1780	2
			3 x 3 x 4	12	24	1700			787	1160	2
M 16	1.60	0.090	2 x 2 x 4	12	24	1700			1370	1912	2
			3 x 3 x 4	12	24	1700			862	1280	2
M 17	1.60	0.090	2 x 2 x 4	12	24	1700			1330	2650	2
			3 x 3 x 4	12	24	1700			630	1130	2
M 50	1.40	0.096	2 x 2 x 4		24	1760				1300	3
			3 x 3 x 4		24	1760				500	3
M 55	1.60	0.090	2 x 2 x 4		24	1760				1425	3
			3 x 3 x 4		24	1760				775	3
M 56	1.60	0.091	2 x 2 x 4		24	1760				1540	3
			3 x 3 x 4		24	1760				1310	3
M 57	1.90	0.089	2 x 2 x 4		24	1760				1630	3
			3 x 3 x 4		24	1760				1330	3
M 50	1.40	0.096	2 x 2 x 4		24	1815				530	3
			3 x 3 x 4		24	1815				460	3
M 55	1.60	0.090	2 x 2 x 4		24	1815				3030	3
			3 x 3 x 4		24	1815				630	3
M 56	1.60	0.091	2 x 2 x 4		24	1815				1150	3
			3 x 3 x 4		24	1815				1360	3
M 57	1.90	0.089	2 x 2 x 4		24	1815				1980	3
			3 x 3 x 4		24	1815				1030	3
M 59	2.25	0.096	2 x 2 x 4		24	1700	10	20		990	2
			3 x 3 x 4		24	1700	10	20		610	2
M 60	2.25	0.096	2 x 2 x 4		24	1700	20			1350	2
			3 x 3 x 4		24	1700	10	20		870	2
M 61	1.52	0.090	2 x 2 x 4	18		1700	20		1400		4
			3 x 3 x 4	18		1700		20	1460		4
M 62	1.90	0.088	2 x 2 x 4	18		1700	20		1500		4
M 63	1.50	0.093	2 x 2 x 4	18		1700		20	1770		4
			3 x 3 x 4	18		1700		20	1460		4
M 64	1.90	0.088	2 x 2 x 4	18		1700	20		1410		4
			3 x 3 x 4	18		1700	20		1630		4
M 65	1.60	0.093	2 x 2 x 4	18		1700		20	1130		4
			3 x 3 x 4	18		1700		20	1130		4

* 1. Hot shakeout and standard addition of 0.01 Te; 0.003 B; 8 gr H_2O/ft^3 — Pretreatment 2 hr 600 F — 4 hr 1200 F.

2. Pretreatment 2 hr 600 F — 4 hr 1200 F.

3. No Pretreatment.

4. Pretreated 4 hr at 600 F; 4 hr 1200 F.

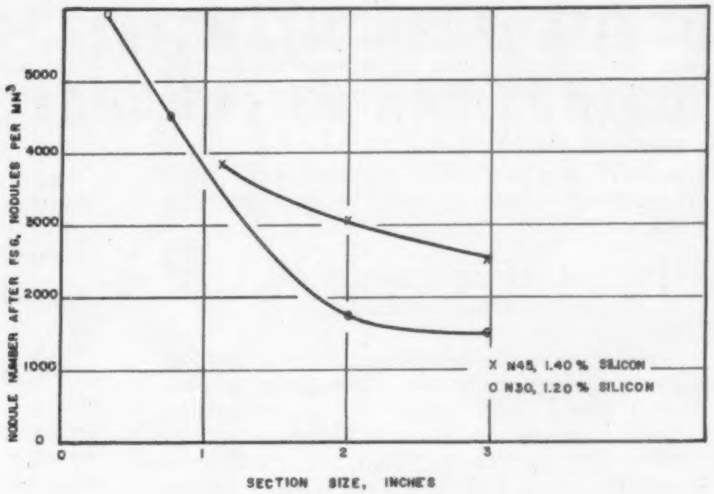

Fig. 5 — Effect of section size on number nodules after FSG in heats N45 and N30. The 2 in. and 3 in. sections represent 2 x 2 x 4 in. and 3 x 3 x 4 in. bar castings, while the 0.25 to 1.125 sections are thin slices cut from the bar castings.

after pouring. They were cooled under an air blast on the mechanical shake out.

6. All of the above combined.

All of these efforts at increasing nodule number failed. They did produce an increase compared with irons not receiving the treatments, but the highest nodule number did not rise above 3000/cu mm, and in most cases remained below 2500/cu mm. From this it appears that the nucleating factors reported in the literature operate most effectively in thin section castings. Certainly this was the experience previously.[3] Thus, it appears there is a mass effect acting against nucleation during annealing. To study this, thin sections were cut from thick as-cast sections and then annealed.

The effect on nodule number in heats N30 and N45 is shown in Table 4 and in Fig. 5. This confirms the mass effect against nucleation. Possible improvement in nodule number and annealability in heavy sections might come from increasing per cent silicon in the iron. This was studied, and the trend is illustrated in Fig. 6. Increasing silicon content results in higher nodule number, as shown in Fig. 6, within the composition range studied. It should be acknowledged that the nodule number, shown on Fig. 6, is a maximum obtained by treatments 1-5 above.

Figure 6 still shows a significantly lower number of nodules in the 3 x 3 x 4 in. casting compared with the 2 x 2 x 4 in. casting. However, even the maximum number of nodules, shown in Fig. 6, is too low for

TABLE 4 — NODULE NUMBER IN SECTIONS CUT FROM HEAVY SECTIONS

Heat No.	Analysis, % C	Analysis, % Si	As-Cast Section, (in.)	Cut Section, (in.)	Addition, %	Nodule Number
N 30	2.28	1.25	2x2x8	¼	0.01 Te	5000+
N 30	2.28	1.25	2x2x8	¾	0.01 Te	4500
N 30	2.28	1.25	2x2x8	2x2x4	0.01 Te	1700
N 30	2.28	1.25	3x3x8	3x3x4	0.01 Te	1500
N 45	2.50	1.40	3x3x8	1⅛	0.01 Te; 0.003 B; 8 gr H_2O/ft^3	3800
N 45	2.50	1.40	3x3x4	3x3x4	0.01 Te; 0.003 B; 8 gr H_2O/ft^3	2560
N 45	2,50	1.40	2x2x8	2x2x4	0.01 Te; 0.003 B; 8 gr H_2O/ft^3	3020

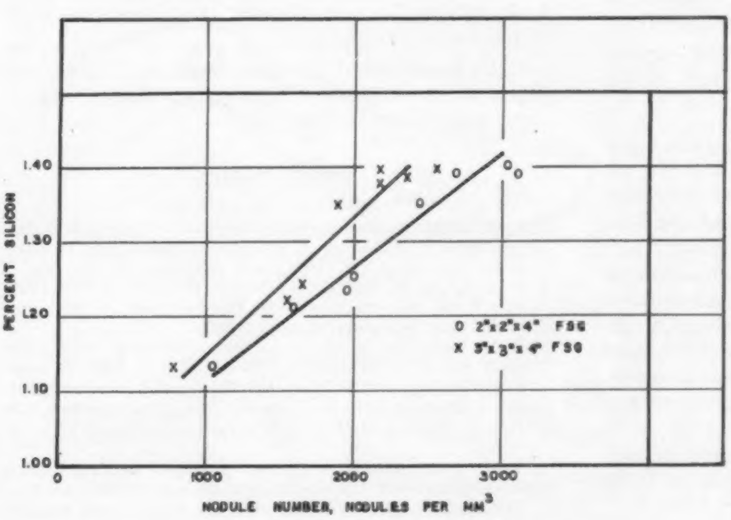

Fig. 6 — Effect of silicon content on nodule number in 2 x 2 x 4 in. bar and 3 x 3 x 4 in. bar castings. This nodule number is developed only with full use of nucleation, tested as 1-6 in the text.

maximum rate of graphitization. Thus the FSG time curves in Fig. 4 for the heavy sections will remain above the minimum curve for light sections, unless some means is found to increase nucleation in heavy sections.

Higher temperature during FSG was considered as a means of increasing nodule number. Temperatures up to 1800 F were of no assistance, as indicated in Table 3.

PHOSPHORUS EFFECT ON ANNEALABILITY

A second major problem of studying FSG and SSG in heavy sections was caused by segregation of phosphorus during solidification. All heavy sections showed phosphide segregation in the range studied, 0.073 to 0.126 per cent P. This made it difficult to detect the end of FSG. Much effort was expended with etching reagents to determine the time required for less than one per cent carbides to remain after FSG, as distinct from residual phosphides that cannot, of course, be graphitized.

This uncertainty of end point is the reason for the rather wide bracketing of FSG time, as shown in Table 3 and in Fig. 4. Low phosphorus content iron would eliminate this problem. Generally the phosphides are fully dissolved after second stage annealing. This may be due to the high solubility of phosphorus in ferrite.

SECOND STAGE ANNEALING

Based on nodule counts after FSG, it was predicted from the previous report[3] that SSG could be accomplished at a rate cooling slower than 20 F/hr and faster than 10 F/hr. This turned out to be true on the heats tested. Heats N46, N49, N50, M59 and M60 illustrate this point. However, in cases of exceptionally low nodule number a cooling rate of less than 10 F/hr may need to be used, although no case of this type was encountered in this work.

CONCLUSIONS

In reviewing the results of annealability experiments with heavy section white iron castings certain facts emerge:

1. A drastic decrease in the number of graphite nodules developed during annealing occurs as the as-cast section size increased. The decrease in nodule number substantially increases the time requirements for FSG and SSG.
2. When Bi, Te or Ce are used for prevention of mottling there is no improvement in the number of nodules developed in heavy sections during annealing. All three are accompanied by low nodule numbers in spite of their different chemical nature. This lends credence to the idea that increasing mass is an anti-nucleating factor, per se.
3. The factors known to cause large increases in nodule number in lighter section castings seem to be much less effective in heavy sections.
4. When thin sections are cut from heavy as-cast sections, they show an increase in nodule number compared to the heavy sections after annealing.
5. Increasing FSG annealing temperature showed no effect of improving nodule number.
6. Only increasing the silicon percentage produces a significant increase in nodule number. This point applies to iron treated with the known methods of increasing nucleation in light sections and to the silicon range studied, 1.13 to 1.40 per cent.

Considering these points, it appears that the FSG times, shown in Fig. 4, are realistic for 2 x 2 in. and 3 x 3 in. bar sections. Further, the minimum FSG time at 1700 F, shown in Fig. 4, for light sections will not be reached in heavy sections until some means are found to increase the nodule number developed during annealing. Second stage graphitization rates hinge on the same problems of nodule number. The maximum rate is about 20 F/hr with the most favorable nodule numbers obtained in this work. Slower rates of 10 F/hr or less are required at the lowest nodule numbers.

Cerium has been revealed as another element capable of producing white fractures at C and Si percentages where mottle or gray fractures would normally occur. The effectiveness of cerium in raising C and Si limits for mottling is similar to that of tellurium, presented in Fig. 2, but the percentage addition required is larger. No chemical analyses are available from this work to determine recovery of cerium.

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SYSTEMATIC APPROACH TO SAND DESIGN AND CONTROL

Progress report 5 — interpretation of data

by A. H. Zrimsek and G. J. Vingas

ABSTRACT

This is an analysis of the interaction of the various physical properties of sand mixtures, considering all data presented in previous progress reports. This interaction of physical properties shows that southern and western bentonite react differently with mulling efficiency and time and wood flour content of the sand mixture. The wood flour addition to southern bentonite bonded sands reduces the density differential substantially, as though less clay is present in the sand than is actually present. Western bentonite, on the other hand, remains unaffected by the wood flour addition.

INTRODUCTION

Considerable data have already been presented in the first four reports of this series, with an even greater amount to be given in the six to eight progress reports that will follow. To those readers possessing a thorough understanding of graphical representation, this is an ideal method for presentation of data gathered for this series of reports. In the previous progress reports all of the principles involved were not brought forth clearly because of the limited nature of the individual report.

The writers feel that at this stage of the series an analysis of the interaction of the various physical properties, considering all the data, is necessary to clarify and accentuate some of the principles brought to light.

RESULTS

The data presented in this report were selected from the previous four of this series. Data are included which emphasize some of the basic principles and characteristics of sand formulation.

DISCUSSION

Although the graphical representation of data in previous reports of the series is straightforward, it fails in some instances to dramatically demonstrate the principles involved. Except for the discussion of green compression to green shear ratios, little mention has been made about the interaction of the various physical properties recorded. The study of relationships of one property to another can often clarify a principle involved.

In the earlier progress reports, the interaction of the various physical properties with water content and ramming energy was presented. An example of this can be seen in Figs. 1a and 1b. These figures show that as water content is increased both green compression and shear first increase in magnitude to a peak, then decrease in magnitude. They also show that rammed density first decreases to a minimum and then rises. As seen in these figures, dry compression and shear rise in magnitude with increasing water.

The figures also show that all properties increase in magnitude with increased ramming energy. This is typical of the data presented. It is apparent that for the system depicted in Figs. 1a and 1b, three ram green compression strengths between 5.0 psi and 16.8 psi can be obtained. This strength range just about covers the range encountered in various foundry operations. Judging by green compression alone, this system could pass the control specification of almost every foundry in the country, but, of course, the sands in this system would not perform satisfactorily in most foundries. Green compression alone does not describe sand quality. No one single physical property does for that matter.

Physical Properties Interaction

The importance of considering the interaction of the various physical properties as a means of sand control and design cannot be overemphasized. Consider the relationship between green compression and dry compression. It is apparent from Figs. 1a and 1b that as water is increased, green compression strength drops and dry compression rises. However, the exact relationship between the two properties is not readily seen. By replotting the 3 ram data of Figs. 1a and 1b, in a form as shown in Fig. 2, the relationship becomes apparent.

By also plotting the 3 ram green and dry relation-

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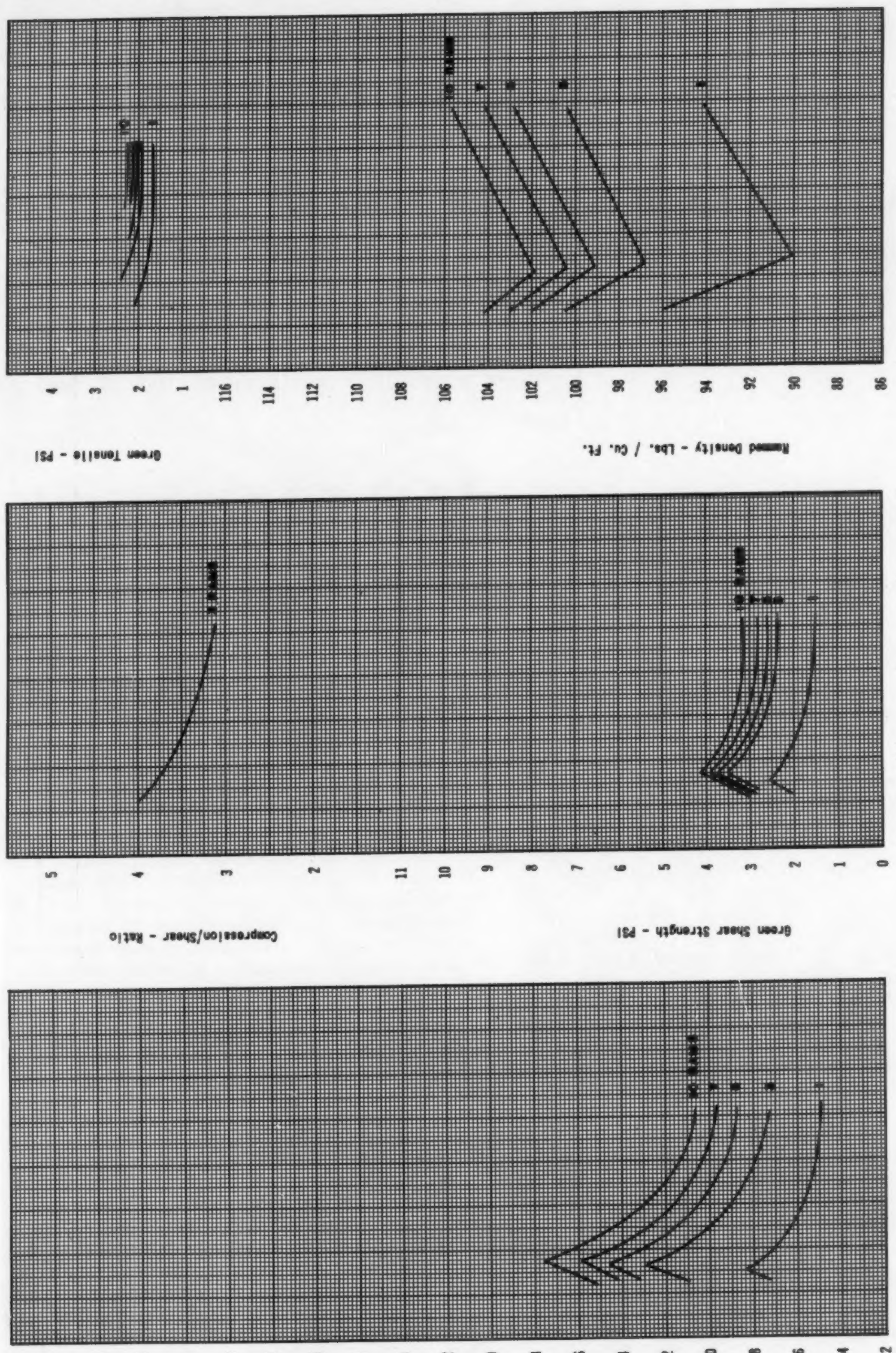

Fig. 1a — Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite bonded Portage silica sand. Mulled 6 min.

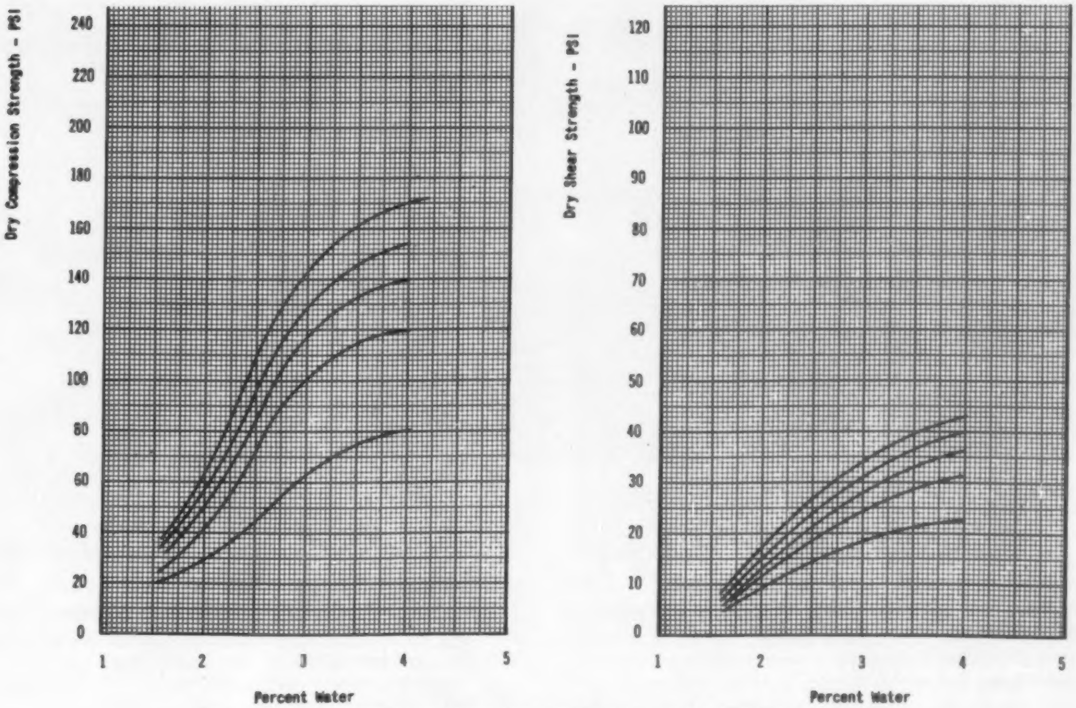

Fig. 1b — Water content and ramming energy effect on physical properties of 4.75 per cent western bentonite bonded Portage silica sand. Mulled 6 min.

ship for 7.45 and 10 per cent western bentonite bonded sands at 6 min mulling, it is possible through interpolation to pick the clay content required to provide a given combination of green compression and dry compression. To obtain a green compression of 14 psi and dry compression of 108 psi, a bentonite content of 7.45 per cent is needed. If the same 14 psi green is desired but only 80 psi dry, approximately 6.2 per cent western bentonite would be required. Almost any combination of green and dry compression strengths can be had by simply changing clay and water contents while holding mulling intensity constant.

This same type of presentation also gives a striking clarification of the importance of mulling control in any sand control program. Figure 3 gives a good picture of the effect of mulling time on changing the relationship of green to dry. Recalling that high dry strength occurs at high water contents, it can be seen that the relationship of green to dry is least affected at high water. It also emphasizes that the dry sands normally encountered in iron foundries are highly affected by changes in mulling efficiency.

The importance of mulling can be further indicated by comparing results obtained from mixtures bonded with 7.45 per cent western bentonite mulled in different sized mullers or with different methods of additions. Compare the relationships of Fig. 4 with those of Figs. 2 and 3, and it becomes evident that addition of water to sand followed by bentonite is a more efficient method of addition as compared with adding water to dry mixture of sand and bentonite.

It can also be seen that the efficiency of the small 12 in. diameter muller is substantially higher than the 18 in. diameter muller. The smaller muller imparts properties to 7.45 per cent western bentonite bonded sands which are comparable to the strengths of 10 per cent western bentonite bonded sands mulled in an 18 in. diameter muller.

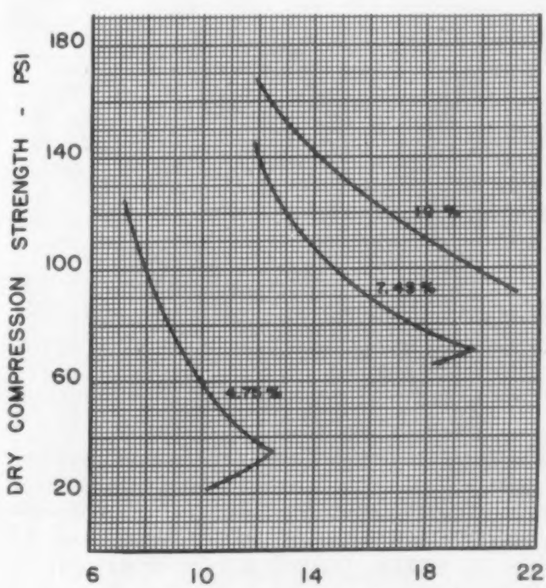

Fig. 2 — Green compression strength vs. green shear strength of 4.75, 7.45 and 10 per cent western bentonite systems mulled 6 min in an 18 in. laboratory muller.

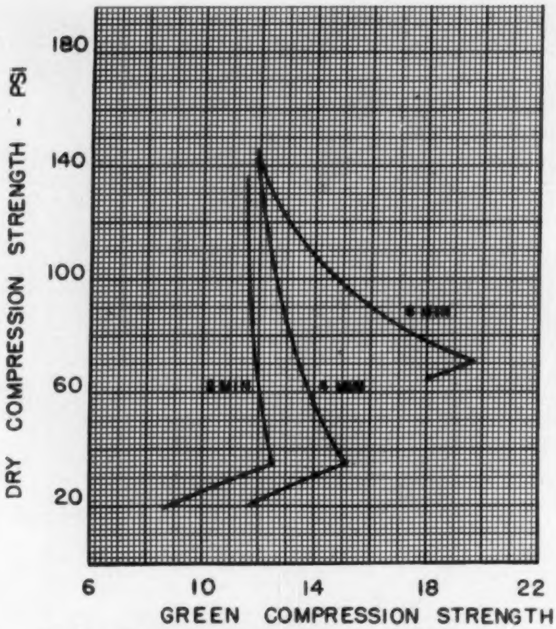

Fig. 3 — Green compression strength vs. dry compression strength of 7.45 per cent western bentonite system mulled for 2, 4 and 6 min in an 18 in. muller.

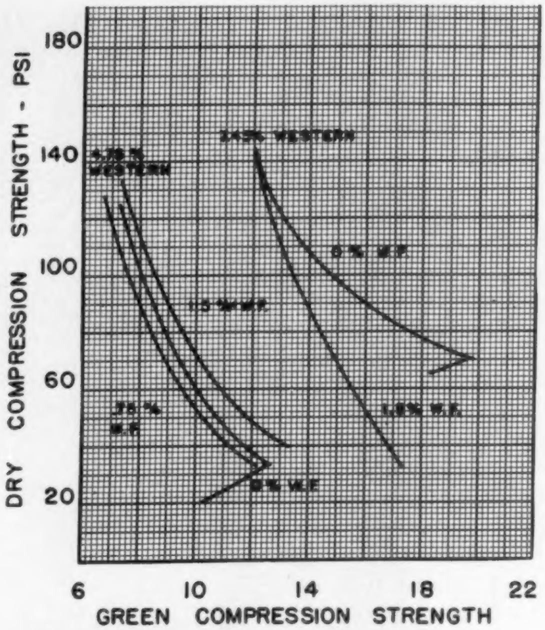

Fig. 5a — Green compression strength vs. dry compression strength of 4.75 per cent and 7.45 per cent western bentonite systems with additions of 0.75, 1.5 and 3.0 per cent wood flour.

Wood Flour Data

When data collected from mixtures containing wood flour are replotted in the form of green versus dry strength, as in Fig. 5, the difference in the effect of wood flour additions on western and southern bentonite can be seen. The relationship of green to dry for 4.75 per cent western is hardly affected by wood flour additions up to 3 per cent. Southern bentonite, on the other hand, is drastically affected by 0.75 per cent wood flour additions, with larger additions up to 3 per cent having little additional effect. The ef-

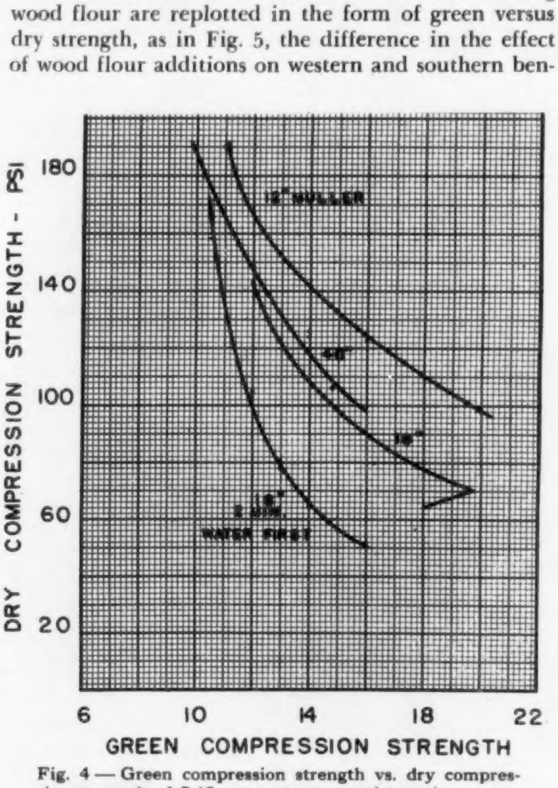

Fig. 4 — Green compression strength vs. dry compression strength of 7.45 per cent western bentonite system mulled 6 min in a 12, 18 and 40 in. muller. Data presented are also for the same system mulled 2 min in an 18 in. mulled with water added first.

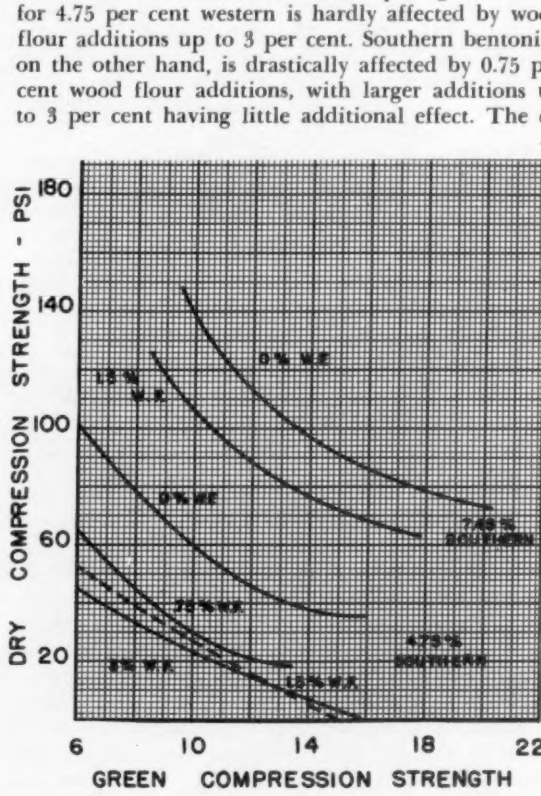

Fig. 5b — Green compression strength vs. dry compression strength of 4.75 per cent and 7.45 per cent southern bentonite systems with additions of 0.75, 1.5 and 3.0 per cent wood flour.

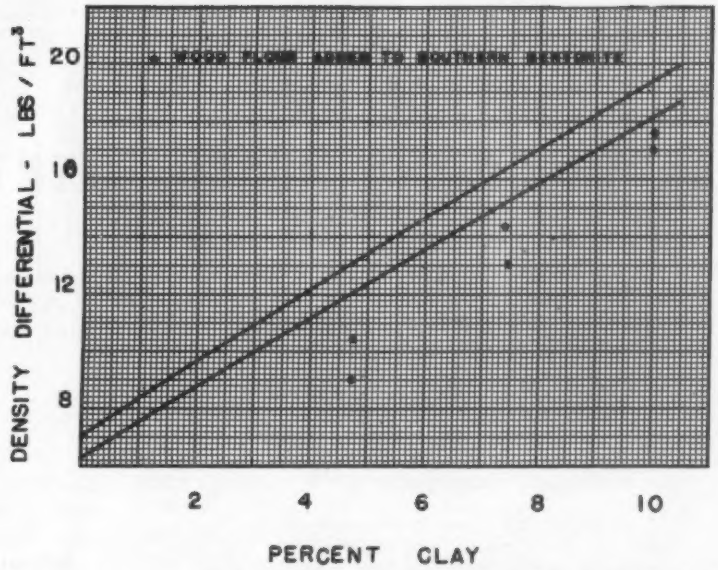

Fig. 6 — One to 10 rams density differential in lb/cu ft vs. clay content of sands bonded with southern and western bentonite and some mixtures in which wood flour was added.

fect of wood flour on higher western bentonite contents is one of retarding mulling. Comparing Fig. 5 with Fig. 3, it can be seen that a 7.45 per cent western-1.5 per cent wood flour combination mulled 6 min has green and dry characteristics similar to a simple 7.45 per cent western sand mulled only 4½ min. This agrees with observations made in progress report 4.

The relationship of green compression strength to green shear has been discussed at some length in previous reports of the series and will therefore not be covered here.

Ramming Effect

In the initial report of this series it was noted that the density differential between 1 and 10 rams remained constant at any given clay content regardless of mulling time or water content beyond that required for minimum density. Subsequent data collected from mixtures containing from 0.75 to 3 per cent wood flour show the 1-10 ram density differential at any given western bentonite content was not altered.

The 1-10 ram density difference for southern bentonite bonded sands was lowered significantly. If the data collected on density differential are summarized, a straight-line relationship between clay content and density differential becomes apparent. This relationship is given in Fig. 5. The great majority of data gathered fall within the band depicted. The addition of wood flour to western bentonite bonded sands did not have the effect of changing this relationship (Fig. 6).

Wood flour additions to southern bentonite bonded sands, however, had the effect of changing the ramming characteristics to resemble lower clay content then the actual one. Some of the density data for wood flour-southern bentonite mixtures are plotted in Fig. 5. If 1-10 ram density differential is an indication of clay content, the data imply that wood flour added to southern bentonite sands lowers the effective clay level.

The validity of this implication seems to be strengthened by the green versus dry presentation made earlier, and also by observation about the change in "feel" of the sands brought about by wood flour additions. Such additions to southern bentonite sands tended to make the sands feel lower in clay content than they actually were.

The interaction between green compression and green shear, green compression and dry compression, and 1-10 ram density differential at this point appear to hold the most significance.

CONCLUSIONS

1. No one particular physical property of sand can adequately describe sand quality.
2. A study of the relationship of green compression strength and dry compression strength accentuates the importance of mulling, clay type and content and the influence wood flour has on clays.
3. The density differential from one to 10 rams is related to clay content in simple sand-clay-water formulations when moisture of the sand mixture is beyond that required for minimum density.
4. The interaction of the physical properties clearly shows that southern and western bentonite react differently with mulling efficiency, mulling time, and wood flour additions.
5. Wood flour addition to southern bentonite bonded sands reduces the density differential substantially as though less clay was present than actually existed in the mixture. Western bentonite, however, remains unaffected.

The above conclusions are based solely on the data and observations collected thus far. Subsequent reports will contain data which will further substantiate the above conclusions or repudiate them.

ACKNOWLEDGMENT

The writers are indebted to Magnet Cove Barium Corp. for permission to conduct the necessary research work to investigate the principles developed in this series and publish the results of these investigations.

LIGHT ALLOY GRAIN SIZE CONTROL AND SUPERCOOLING MEASUREMENTS

by V. B. Kurfman

ABSTRACT

A simple cooling curve determination is described which has shown supercooling effects up to 15 F in commercial purity magnesium and aluminum alloys. These high supercooling values are related to coarse grain size.

The effects are large enough to allow use of the method for quality control of grain refinement processes. In some cases, off composition melts can be analyzed by inspection of the resulting curve.

A complete measurement can be completed in the melt room within 1-2 min.

Data are presented for Mg-Al, Mg-Zn, Al-Si, Al-Cu and Al-Mg.

INTRODUCTION

Supercooling or undercooling is a well known phenomenon in pure metals and certain alloys. The best known modern studies of the subject have dealt with homogeneous nucleation in small isolated droplets of clean metals. Under these conditions supercooling of about 18 per cent of the absolute melting point has been observed.[1] Nucleation then occurs, the droplets solidify liberating the latent heat of freezing and temperature rises to approach the liquidus temperature, i.e., recalescence occurs.

Considerable interesting work has also been done on supercooling of larger melts in which large effects are observed. In Walker's work on Ni,[2] as in that on Fe by Barbenheur and Bleckmann,[3] the necessity for keeping the melt undisturbed and free of chance nucleants is stressed. Cibula reported some supercooling of coarse grained Al alloys cast in a sand mold.[4] He noted that the addition of various grain refining agents eliminated this effect.

The theory of homogeneous nucleation and supercooling has been well described by Turnbull.[1] Heterogeneous nucleation is of more importance in the freezing of castings. However, the theory is not so well defined. The work of Chalmers and his associates[5] treats the interaction of such nuclei and supercooling. The "constitutional supercooling" concepts have been given a rather detailed theoretical exposition in treating the interaction of thermal gradient, heterogeneous nuclei and diffusion barriers to freezing.

The interaction of supercooling with nucleation or grain refinement processes in commercial practice remains rather vague. The magnitude of the effects which may occur, their relation to the final grain diameter of the casting and the supercooling necessary or sufficient to allow the use of a given grain refinement agent is generally unspecified.

During the present study, it has been found possible to observe supercooling in commercial casting alloys of as much as 15 F (8 C), using simple techniques and few special precautions. It is possible to use this sort of measurement to estimate the grain diameter of various casting alloys, or at least to determine if a melt will be coarse grained.

EXPERIMENTAL PROCEDURE

The melts described are magnesium- or aluminum-base alloys prepared according to commercial practice from standard commercial purity materials. The treatment of the melts was according to production procedure except for cases in which deliberate grain coarsening was attempted.

The cooling curve samples were taken in thin-wall armco iron crucibles of 20 cm^3 capacity, i.e., 30-35 gm of liquid Mg. A standard glass-coated iron-constantan thermocouple with a stripped and twisted bare metal junction was used with a strip chart recorder operated at 12 in./min chart speed. Relative temperatures were estimated to $\pm$ 1 F with this equipment. For absolute liquidus temperature determinations, the recorder was standardized against an indicating potentiometer, and in some cases calibrated against the melting point of sublimed Mg.

A selected coil of thermocouple wire was reserved for the measurements, and for any given series of cooling curves a sufficient length of wire was installed to allow its continued use by clipping off the inch or so of wire lost in the sample. In no case did the recorded melting point for sublimed Mg deviate more than $\pm$ 2 F from the literature value of 1202 F (650 C).

For the magnesium alloys the sample was dipped from the melt, dusted with an agent to prevent burning and allowed to air cool in a sheltered position.

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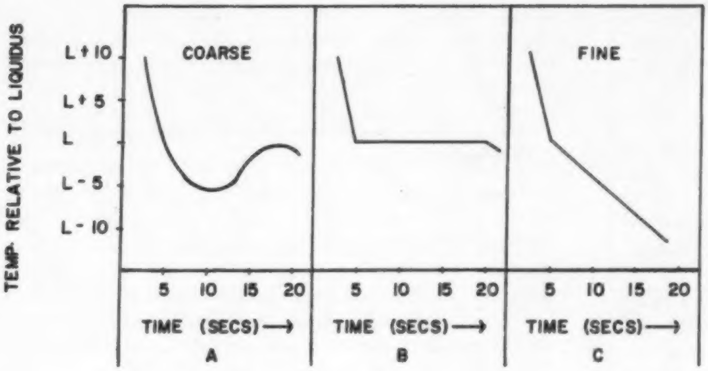


Fig. 1 — Types of liquidus arrest observed on rapid cooling.

The cooling rate prior to freezing was typically 240 ± 15 F/min.

For the aluminum alloy samples the crucible and the thermocouple junction were lightly coated with red mud to inhibit attack on the steel. The melt surface was not protected.

RESULTS AND DISCUSSION

A representation of typical cooling curves is shown in Fig. 1. Three forms of liquidus arrest are shown — one in which distinct supercooling occurs with recalescence to the liquidus temperature, one in which the arrest does not detectably deviate from horizontal and one in which the curve extends smoothly downward in temperature at a substantially reduced slope from the pre-liquidus portion.

For this discussion, the melt supercooling is considered to be the height of the recalescence pip in Fig. 1a, the difference in temperature between the lowest point reached before the reheating occurs and the highest subsequent point. This is not strictly correct, for some supercooling is certainly concealed in the curve in Fig. 1b. If no supercooling occurred, one would expect a curve of the third type (Fig. 1c).

Supercooling as a Grain Size Function

A few data points are shown in Fig. 2 to illustrate the relation of supercooling to grain size. For Mg-Al alloys which supercooled more than 1 F (0.6 C), the grain diameter of the cooling curve sample was consistently more than 0.015 in. Conversely, for samples having an average grain diameter more than 0.015 in., supercooling of at least 1 F (0.6 C) was nearly always observed. Also, melts showing a supercooling of 4-7 F (2-4 C) usually had an average grain diameter (A.G.D.) greater than 0.1 in. Grain diameters for melts showing no detectible supercooling (less than 1 F) ranged from 0.005 in. to 0.015 in.

Four different grain refinement treatments were used for magnesium-base alloys, and in all cases measurable supercooling was eliminated when sufficient refinement occurred. The processes used were the addition of Zr to Mg-Zn, Mg-Th or Mg-rare earth, the addition of C to Mg-Al, the treatment with Cl_2 of Mg-Al and the superheating of Mg-Al.[6] Data points indicated as grain refined in Fig. 2 resulted from such treatments on AZ91.

All grain coarsening treatments tried were effective in producing observable supercooling. Mg-Al alloys which have been grain refined by superheating or carbon treatment can be coarsened by the addition of trace amounts of Be or Zr. Either addition yielded several degrees of supercooling in alloys containing more than 3 per cent Al.

Aluminum-base alloys can be conveniently grain coarsened by holding at high temperatures, and all Al system alloys examined containing more than four per cent solute showed at least 5 F (3 C) supercooling on holding at 1500 F (816 C) after chlorina-

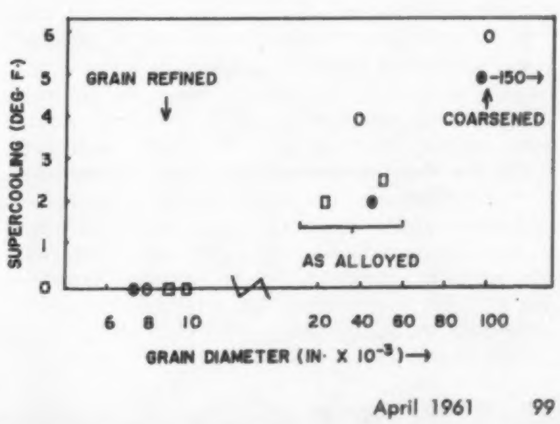


Fig. 2 — Supercooling vs. average grain diameter (AZ 91). Grain refinement — black circle, superheat; white circle — Cl_2; square — C.

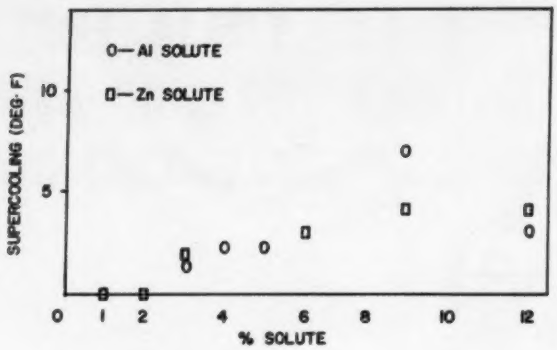


Fig. 3 — Maximum supercooling vs. binary composition Mg-base alloys.

tion at 1350 F (732 C). Examination of grain refinement treatments was not attempted for aluminum-base alloys, except to note that a previously overheated melt showed some refinement on holding at 1400 F (760 C). The refinement was easily seen from the cooling curves as well as metallographically.

Supercooling as a Solute Function

Mention was made of the importance of solute concentration in determining how much supercooling might occur in a coarse grained alloy. To clarify the role of solute concentration, a series of alloys was prepared in the Mg-Al, Mg-Zn, Al-Si, Al-Cu and Al-Mg systems. An effort was made to grain coarsen these alloys as much as possible to determine the maximum observable supercooling as a function of solute concentration. The Mg-base alloys were coarsened by addition of Be and the Al-base alloys by chlorination and overheating. The data are shown in Figs. 3 and 4, where all data points refer to the observed supercooling for samples coarser than 0.1 in. A.G.D.

In no case was supercooling observed with pure Mg or Al, even though extremely coarse grain structures occurred. The maximum undercooling observed increases with composition up to some value where a leveling off or even a decrease may occur, as shown.

Cause of Supercooling

The results presented can be explained in terms of the heat balance associated with the growth of suitable nuclei, and the various barriers to the growth of such nuclei.

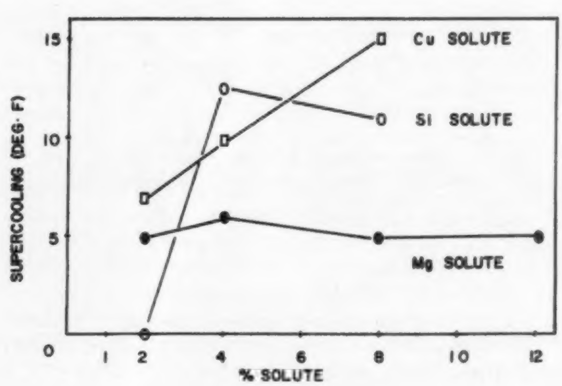
In the pure metals and dilute alloys, crystallite growth rates can be extremely high. The growth of a few grains, perhaps initiated at the crucible wall, is sufficiently fast to liberate latent heat as fast as the sample is cooled. However, for higher concentration alloys, freezing tends to take place below the equilibrium temperature. Solute is rejected, according to phase diagram relationships, around the growing crystals.

This depresses the melting point, and if freezing is to proceed it must occur at a temperature corresponding to the liquidus temperature of this solute-rich region. This can allow the bulk liquid to undercool sufficiently for fresh nuclei to begin growing.[5,7]

If enough nuclei grow, they can liberate latent heat faster than the sample is cooled and the temperature may actually rise, approaching the equilibrium liquidus.

A temperature measurement taken just in the nucleation region would indicate the maximum supercooling resulting from these diffusion barriers to growth. It makes no difference then if nucleation occurs at the crucible wall since the solute-rich bound-

Fig. 4 — Maximum supercooling vs. binary composition Al-base alloys.



ary layer can isolate the crystals in that region. Hence, rather large supercooling effects can be observed even if the crucible material is a nucleation catalyst for the melt, and the occurrence of such effects in iron crucibles is not surprising, for high solute alloys.

Furthermore, it is of little consequence whether or not the thermocouple nucleates the melt. If the diffusion boundary is to be an effective barrier to crystal growth, the solidification of metal on the thermocouple wires must proceed at substantially the reduced temperature which characterizes the freezing of the balance, until recalescence begins.

The failure to observe supercooling in dilute alloys then is attributed to the failure to achieve stable diffusion boundaries. In more concentrated alloys, supercooling is observed unless the melt is well nucleated. If the melt is grain refined, enough growth sites are available with nominal supercooling to balance the rate of heat removal and permit freezing to proceed smoothly with no recalescence effect.

Validity of Measurements

The isothermal liquidus arrests sometimes seen (Fig. 1b) require an evaluation of the maximum thermal gradient which may occur across the sample. Several attempts were made to measure this effect, and none was detected. The use of an unshielded thermocouple may permit shorting out, which would prevent measurement of the surface versus interior temperature so a trial calculation was made.

The maximum gradient may be calculated on a basis of uniform heat flow from a knowledge of the cooling rate. Since a sphere contains a maximum of volume per unit surface, the maximum gradient at the sample surface can be calculated based on the measured cooling rate assuming a spherical sample of equal volume. Using a cooling rate of 4 F/sec, Mg heat capacity of 0.32 cal/deg. C/gm, liquid Mg density of 1.6 gm/cm^3 and thermal conductivity of 0.2 cal/cm^2 deg. C/cm/sec, the surface gradient is calculated to be 3.1 C/cm. The radius for a sphere of 20 cm^3 volume is 1.7 cm, and, assuming a linear decrease in gradient to the center of the sphere, one calculates a maximum surface to center temperature difference of 5 F (2.7 C).

If recalescence should begin at the sample surface before that region is undercooled 5 F (2.7 C), then the reheating would prevent observation of any undercooling at the sample center. This effect would appear as an isothermal arrest on the cooling curve, as was often observed for moderately fine grain samples (Fig. 1b). It would also be possible that a sample showing 5 F (2.7 C) recalescence would actually have experienced an additional concealed supercooling of 5 F for a total of 10 F (5.4 C).

This concealed supercooling may then account for the failure to get a better correlation between grain size and cooling curve for samples finer than 0.015 in. A.G.D. There may be a wide range of grain sizes from 0.005-0.015 in. A.G.D. corresponding to such a concealed effect in the range 0-5 F (0-2.7 C). Undercooling greater than this has been associated in all cases with coarse grain samples.

Use of the Method

The possible utility of this method as a control for grain diameter lies in its speed. If a melt is being held on the melt floor at say liquidus plus 200 F, then a supercooling measurement may be completed within one min of the time the sample is removed. This is even faster than the speed with which a fracture bar can be cast, broken and examined. Furthermore, this test can be quantitative, and, thus, can provide an objective measure for quality control under favorable circumstances.

The chief disadvantage of the method, apart from the equipment necessary, is that one may not have free choice of the control point. For example, Mg-Al alloys can only be categorized as coarse or not coarse from the direct measurement of recalescence. This is a result of the concealment of a certain degree of undercooling in relatively flat liquidus arrests. Work is now in progress to clarify this point and permit extension of the method, and current results show some promise.

Nevertheless, for a foundry or laboratory which has moderately high speed temperature recording equipment available, the cooling curve will distinguish the grain size effects mentioned. In the processing of any particular melt which must have grain size controlled by some transient process (as for example superheat grain refined Mg-Al melts), knowing whether or not the grain refinement treatment is present when the melt is ready to pour may save scrapped castings.

Binary Metal Analysis

A further possibility exists for those who may have such equipment available. For many binaries it is possible to obtain a useful analysis from an estimate of the liquidus temperature of the heat. This may also be true of complex alloys if the control of one element is the major problem. Such an analysis may sometimes be used only as a temporary expedient to allow processing of a heat to proceed without waiting for a chemical or spectroscopic analyses.

For example, in Mg-Al alloys through most of the commercial range, one per cent Al will depress the liquidus about 12 F. The measurement of this temperature by the technique described will allow the estimation of Al to $\pm \frac{1}{2}$ per cent, if the temperature measurement is accurate to $\pm$ 5 F. With good, calibrated equipment it is certainly possible to do much better than this. However, such refinements are often not necessary in production foundry operations.

A foundry running gas control specimens might be in the best position to use this sort of tool. The recording equipment could be kept with the gas testing equipment and both units operated by the same technician.

This type of measurement has been used primarily in our laboratory in the investigation of grain refinement treatments. It has been found most valuable in following transient grain size effects wherein the timing of some melt treatment may depend on the melt response to a prior treatment. It has also saved a number of off-composition experimental melts.

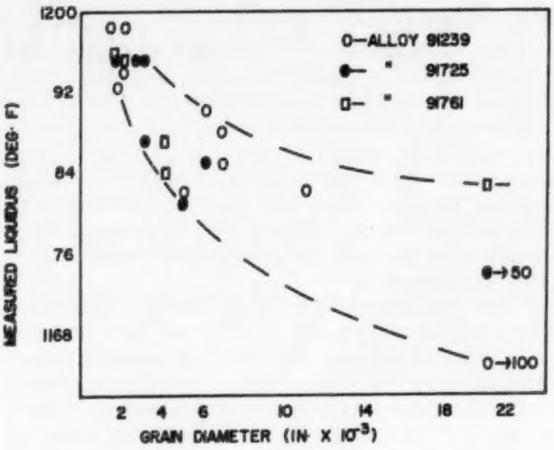


Fig. 5 — Grain diameter of EZ33 vs. liquidus temperature.

The estimation of the liquidus temperature has enabled the alloying errors to be found and corrected. It happens that this laboratory facility is not set up for routine analysis of melts before processing, as is done in the production facility. To do this type analysis in the laboratory requires holding a technician and his equipment available on a stand-by basis, which becomes excessively expensive for most routine experimental work.

MgZr Grain Size Control

A final example of cooling curve utility in predicting grain size effects deals with MgZr alloys. Certain of these alloys, notable E33, are sensitive to grain size control for the achievement of optimum properties. Zirconium is added to control the grain size, and an addition of about ½-1 per cent Zr is sufficient to reduce the A.G.D. in this test specimen to ± 0.010 in. and eliminate the recalescence. Further additions of Zr allow reduction of grain size to 0.0015-0.003 in. in the particular specimen studied, with some further change in the shape of the cooling curve. More important, Zr in Mg is a peritectic grain refiner, and its addition substantially raises the liquidus temperature.

Figure 5 shows the liquidus temperature as a function of A.G.D. for EZ33. It is clear that a good correlation exists between the observed liquidus temperature and the metallographically determined grain size. The result is of interest primarily because of the good correlation between grain size and liquidus temperature for a quaternary alloy. Most foundrymen would probably not care to base their grain size control on the estimation of temperature to ± 2 F.

The first addition of Zr (one-half per cent in this series) is sufficient to eliminate supercooling as measured by recalescence. However, the steady progression in liquidus temperature with increasing Zr content allows the development of a much better correlation.

CONCLUSION

A rapid open-air cooling curve test is sufficiently sensitive to detect supercooling effects of the order of 1-2 per cent (½-1 C) or more.

This amount of supercooling characterizes coarse grained alloys in the MgAl, MgZn, AlSi, AlCu and AlMg systems of commercial interest, and its measurement can be used as a tool for grain size control. Supercooling disappears in grain refined melts, and reappears when the metal is grain coarsened. Supercooling increases with increasing alloy content to a maximum which appears to be characteristic of the alloy system for coarse grained alloys.

There is no apparent reason why the method could not be extended to other alloys, providing the solute content is sufficient. Where this method is used to follow grain size effects, a crude liquidus temperature estimate is also provided, enabling melt analysis to be read from the phase diagram for simple alloys.

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PERMANENT MOLD DESIGN

by John Wall

ABSTRACT

The advantages of the permanent mold process are detailed by the author. He covers such items as gating and risering design, mold coatings use and shrink factors, as well as some automotive uses of this process.

INTRODUCTION

The principal of permanent mold casting has changed little since one of our prehistoric ancestors first cast a crude axe head by filling a cavity between two stones with molten metal. The technical advances have, however, been vast.

Permanent molding, or gravity die casting, as it is more properly called in the European countries, is used in the production of both nonferrous and ferrous castings. We are concerned only with the nonferrous metals, and the general term permanent molding includes all the various phases and techniques in the process.

When the permanent mold is used with sand forming part of the casting, it is called semi-permanent molding. When the mold is spinning as the molten metal is introduced, it is called centrifugal casting. When the metal is forced into the mold by pressure on the surface of the molten bath, it is called low pressure die casting. When the molten metal is poured into the hinge part of a book type mold, and the mold is closed upon the molten metal, it is called compression molding.

While trying not to indicate the superiority of one method over the other, there are distinct advantages for using each process in certain definite applications.

PERMANENT MOLD ADVANTAGES

The permanent mold process is used with advantages for a number of reasons, but usually to cast large numbers of parts that require closer tolerance and better surface finishes than can be obtained by sand casting. As the chilling rates are much higher in the permanent mold, it produces a casting with better metallurgical characteristics and higher mechanical properties than can be produced with sand molds. This same rapid chilling rate also increases the production rate of the permanent mold.

Most of the casting alloys will show their maximum mechanical properties when gravity poured into a metal mold. The ideal gating of the permanent mold will fill the cavity with a minimum of turbulence to reduce the absorption of gases, dross formation and mold erosion. It should regulate the rate of metal entry into the cavity, to establish the best possible temperature gradients to promote progressive solidification and produce a casting with minimum excess metal in the gates and risers.

The design of the gating and risering of a permanent mold casting is becoming increasingly important, not only to produce a sound casting, but for ease in gating removal by automatic trimming devices. This becomes important in the high production of automotive parts.

The gating must also be designed to be adaptable to automatic ladling, which is becoming increasingly popular as the size of the castings increase, making manual handling of large amounts of molten metal troublesome.

This can be accomplished in various ways, usually by designing the gating with a runner system allowing the molten metal to be poured into a common funnel, and distributing the metal to the various ingates. In some cases, especially in long thin castings, particularly those requiring sand cores, it is beneficial to allow the mold to be tilted during the casting process to reduce turbulence and provide a more suitable position to install the sand cores. In these instances, a refractory lined and heated ladle can be installed integral with the mold. A measured amount of molten metal can be automatically poured into the ladle when in the horizontal position. As the mold is tilted from the horizontal position at a controlled rate, the molten metal is automatically poured into the cavity until the casting cycle is completed and the mold is in the vertical position. This type of mold is easily automated and adaptable to a single pouring station, rotary table type of casting device.

Automated Permanent Molds

Since the use of large permanent mold castings in the automotive industry has been greatly increased, the design of the permanent mold has changed from the simple hand operated, low productive device, to a highly automated self contained casting machine, competitive, especially in the larger castings, with the production rates of pressure die casting. The inconsistencies of the human element have been removed by automatic ladling, mechanical timers and automatic mechanical mold operation. It is possible for the modern permanent mold device to contain automatic insert heaters, dispensers and core extractors. Automatic ejection and casting unloading is common.

The use of mold coatings, which is so necessary in the permanent mold process, still requires some artistry in application. The proper use of the proper materials can easily determine the success or failure of the process. There are many commercial mold coatings now available. At one time each foundry made their own secret formulas, and helped retard the growth of the permanent mold by intimating there was a secret to the operation of a successful permanent mold. There is no secret formula for the operation of any casting operation other than just

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plain common sense. There are many successful permanent mold foundries in operation today, that prior to their entering this field had no practical foundry experience.

There are several reasons why the use of mold coatings are necessary. Basically, they are to prevent erosion of the mold, provide a release agent, insulate the molten metal against chilling too quickly and provide chilled areas to promote progressive solidification.

Mold coatings that are of the insulating type usually contain whiting, kaolin or china clay in a solution of sodium silicate and water. The chill coatings contain graphite. Each permanent mold may require mold coatings with specific properties so the formula is varied with the application. The mold is usually heated to approximately 400 F (204 C), the mold coating sprayed on in thin layers to the required depth, rarely greater than 0.010 in. In localized areas requiring chilling, the mold coating is removed entirely with a wire brush, steel wool or scraper or the thickness of the coating is reduced to a minimum to prevent mold erosion.

The gating and risering are usually heavily coated for maximum insulation. This can be sprayed on or painted on by hand with an ordinary small paint brush.

In a normal permanent mold, no further heating or chilling is required. However, in some instances copper, brass or air chills are needed in localized areas to promote solidification. Because the molds are usually made of heat resistant cast iron, water chilling is seldom used.

In some cases, local areas require additional heat to increase fluidity and prevent misruns and cold shuts. This can be accomplished by the use of gas burners or electrical heaters mounted to the outside of the mold sections in the area requiring the heat.

Automotive Piston Molds

In special cases, as in the highly developed permanent molds for high production such as the automotive piston, various unique devices are used to insure continuous trouble free operation. Many of the devices although, they are peculiar to piston casting, are worth mentioning as they can be applied to other methods of casting.

With few exceptions the automotive piston is cast with a collapsible core made of 5 sections. Depending on the design of the piston and the clearances allowed, the collapsing sequence of the core is a cleverly designed and accurately machined tool, allowing the center section to collapse and be easily extracted from the casting. One side section is then moved into the void created, in many cases with little clearance, and then removed from the casting, allowing the other side sector enough clearance to be removed readily.

The core segments are made of H-13 type hot work die steel with the wear surfaces and keys nitrided to prevent galling. The center part of the 3 piece center core is water cooled, the other parts of the core being cooled by convection.

The outer surface of the piston is formed by a rather simple 2 piece parallel actioned mold. The upper part of this mold forming the ring belt area is usually made of a mild steel allowing this part to be water cooled. The lower part is usually made of heat resistant type of cast iron. This part may contain some complex inserts, and provides locations for the wrist pin cores. Because the outer molds contain the gating and risers and is water cooled, some provision must be made to insulate the gating area from the chilled area. This is accomplished by a simple saw cut divorcing the area adjacent to the gates and risers from the chilled area.

Shrink Factors

Because the operating temperature of the permanent mold segments may vary considerably, greater attention must be paid to the design of the mold in regard to the clearances, shrinkages and mold register than in most other types of casting. Often it is necessary to use several shrink factors for different areas in the same casting. It is normal for adjacent mold sectors to operate at a difference in temperature as much as 400-500 F (244-260 C), making operating clearances a design problem.

Because of this same temperature difference, great attention in the design of the register of the mold components must be made to promote accuracy and continued trouble free operation.

Although emphasis may be placed on the selection of materials to reduce warpage of the mold sectors during operation, it is common for the various components to warp, twist and grow, especially when new. Usually the mold will stabilize after several operations and little further warpage or growth will be experienced. Normally, the mold is adjusted or reworked at this point in case the casting has been affected dimensionally by the warpage of the segments.

Constant vigilance must be maintained as it is a common human trait to spray the mold with mold coating often to correct small defects that may appear in local areas. This leads to a gradual build up of mold coating in certain areas, affecting the dimensional accuracy of the casting.

The ultimate goal of many high production castings is, of course, pressure die casting. However, as mentioned previously, most of the casting alloys will show their maximum qualities when gravity poured. This and a number of other reasons places in doubt the advantage of pressure die casting such castings as the V8 engine block. The block casting can be designed to eliminate all the sand cores and collapsible cores to make it possible to pressure cast. However, the production rate of the pressure cast would not be greatly improved over the permanent mold, especially where inserts must be heated and cast in place, such as bearings and cylinder sleeves.

Although recently there is a lot of interest shown in the pressure casting of the aluminum cylinder blocks for automotive engines, the permanent mold process seems secure in its position. This is mainly because of its lower initial cost, superior properties of the casting, ability to cast heat treatable alloys and a greater selection of castable alloys, shorter lead time, necessary to produce the mold and the improved cycle time of the modern automated mold.

METALGRAMS

UNION CARBIDE METALS

. . . news of "Electromet" ferroalloys and metals

APRIL, 1961

STEEL CASTING QUALITY IMPROVED -- "To meet our quality standards, we have developed a furnace practice that yields P values greater than 75 for Grade B steel," said Harrison Steel Castings Co., Attica, Ind. "Calcium-manganese-silicon helps us get consistently high reduction-in-area values. These in turn raise P values well over 75 -- our minimum quality requirement." Harrison's practice: 4 lb. ferrotitanium and 4 lb. calcium-manganese-silicon per ton for acid open-hearth steel. 3 lb. aluminum and 4 lb. calcium-manganese-silicon per ton for acid-electric steel (until conversion of furnaces to basic). Results: improved fluidity, ductility, and low-temperature impact strength.

* * *

RESULTS TELL STORY -- In 1959, Harrison made 2,028 tests on Grade B steel made in the acid open-hearth. Average P value was 81.8 (76,499 psi tensile strength and 55.4 per cent reduction-in-area). Average impact strength at -20 deg. F. was 17.6 ft.-lb. Similarly high results have been obtained on steel made in the acid electric furnace. For more details, write for the article, "Ca-Mn-Si Boosts Casting Quality," in the Winter-Spring 1961 issue of UNION CARBIDE METALS REVIEW.

For more information circle 150 on page 129-130

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SULPHUR CONTROL IN CAST IRON -- Because foundry coke and scrap introduce sulphur, cast iron often contains up to 0.12 per cent or more sulphur. In the absence of enough manganese, iron sulphide forms, reducing machinability and causing misrun castings. Managanese forms manganese sulphide instead. This compound has little effect on properties, removing the adverse effects of sulphur. A 6-to-1 manganese-sulphur ratio insures sulphur neutralization. Convenient additions of "EM" ferromanganese or silicomanganese briquets to the cupola are widely used for sulphur control. For briquet specifications, write for F-20,066.

For more information circle 150 on page 129-130

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A WORLD-WIDE SEARCH -- The search never ends for high-grade ores, from which ferroalloys are made. Exploration teams of Union Carbide Ore Company search all parts of the world -- sometimes through tropical jungles, arid deserts, and unexplored rivers. Their goal: to discover new deposits to satisfy the growing demand for ferroalloys. Union Carbide's integrated mine-to-furnace operations assure a continuous supply of ferroalloys...when you want them. For the full story, write for the article, "From Earth to Hearth," in the Winter-Spring 1961 issue of UNION CARBIDE METALS REVIEW.

For more information circle 150 on page 129-130

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UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Ltd., Toronto.

NEWS and VIEWS

Bay Foundries Open Plants
Outline Technical Program
Vienna Host to International

65th Castings Congress Highlights Latest Research Points Way to Foundry Technology for Profit

George Mason

Post-Congress Hawaii Speaker

Foundrymen and their wives attending the concluding session of the 65th Castings Congress to be held May 15 in Hawaii, will hear George Mason speak on "The Industrial Future of Hawaii."

Mason, director of Economic Developments for Hawaii, will appear in the Robert Louis Stevenson Room of the Princess Kaiulani Hotel in Honolulu.

On the March 1 closing date, 93 persons indicated their intentions to participate in the Post-Congress Tour and Adjourned Session.

Advance Registration

Avoid delays at the Castings Congress by registering in advance. Return forms to AFS Headquarters with $5 for each person attending. If received by April 10, official badges will be mailed in advance of the Castings Congress. Admittance to the Congress and technical sessions is by badge only. Advance registration is required for making housing applications. Send housing forms to: AFS Housing Bureau, Room 300, 61 Grove St., San Francisco 2.

Industry-Wide Technical Program Previews Future Processes, Alloys, Opportunities

New market opportunities through basic research, modification of current techniques, and a re-examination of fundamentals are promised foundrymen attending the 65th Castings Congress. The annual Convention will be held May 8-12 at Sheraton Palace Hotel, San Francisco.

Approximately 100 technical papers representing all fields of the industry will emphasize research for progress which alert foundrymen will translate into technology for profit.

What makes the Castings Congress the top metalcasting event of the year? AFS Technical Director S. C. Massari states: "One factor is its prestige which annually attracts contributions from outstanding American as well as international authors. A second reason is the scope of the program."

All of the industry's segments are represented with the selection of the papers performed by experts. Each Castings Congress paper must be approved by the respective Program and Papers Committee made up of authorities donating their time to promote the future of the foundry industry. Each paper must meet the standards set forth by the committees representing foundrymen and research personnel, and the established publication policy of the Society.

The following divisions were sponsor papers:

Light Metals
Brass & Bronze
Gray Iron
Malleable
Pattern
Sand
Steel
Die Casting & Permanent Mold
Ductile Iron.

Technical sessions will also be sponsored by the following general interest committees of the society.

Fundamental Papers
Heat Transfer
Industrial Engineering & Cost
Plant & Plant Equipment
Safety, Hygiene and Air Pollution.

Near record attendances at recent regional foundry conferences demonstrates the keen interest in the current and future foundry developments. What will they learn?

New market opportunities for foundrymen lie in the adoption of new techniques, alloys, and processes. Considerable research has been done by Castings Congress authors in exploring new areas for practical application.

Commercial possibilities are seen for . . . lightweight cellular materials having a density of only 20 per cent of the base alloy . . . cast uranium alloys which have the best combination of strength and high density of any known metal . . . investment casting of magnesium alloys . . . permanent molding of lighter, thinner, stronger aluminum castings . . . increased use of aluminum-silicon alloys through phosphorus refining of primary silicon crystals . . . expanded use of Ni-Al bronzes through solving of fabrication and welding problems.

New techniques or modifications are forecast for . . . direct reduction of pig iron from medium grades of iron ore, non-coking coal and limestone . . . production of more stable, less expensive bronze alloys with low frequency induction melting . . . rapid extension of the hot core box process . . . determination of the hydrogen content of aluminum alloys before pouring.

Basic research provides answers for some questions and poses other problems . . . investigation in the effect

of grain size on properties of green sand casts doubt on the widely accepted statement that green compression strength increases as the median grain size increases . . . questioning of the belief that clay distribution is assumed to be better when green strength increases . . . minimizing of the influence of some trace elements in the graphitization of malleable iron.

Technology for profit is available through such investigations as . . . definite recommendations for elimination of defects in aluminum die castings . . . gating systems to produce x-ray sound castings . . . a study of investment casting techniques . . . supercooling measurements and grain size control in light alloys . . . use of calcium carbide in acid cupolas for faster, more economical iron production . . . a review of published data on metal flow and thermal equilibrium in die castings . . . how slight changes in shape and size by design significantly increase the load carrying ability by decreasing applied stress.

Research projects on which progress reports will be given include those sponsored by the Brass & Bronze Division, Gray Iron Division, Steel Division, and Malleable Division. Fundamental principles are incorporated in these research projects.

What are the advantages of attending the various technical sessions? One of the prime benefits of publishing TRANSACTION papers prior to the Congress is the stimulation of question and answers following the talks.

One suggestion for getting the most out of the Congress is to be familiar with the technical papers, then developing a series of questions for a fuller understanding of the subject. Abstracts or the technical papers will be found in the May issue of MODERN CASTINGS, enabling foundrymen to select sessions of particular interest.

In addition to the technical talks, those attending will be able to participate in the shop courses, luncheons, plant visitations, and other Congress highlights.

Luncheons will be held by the following divisions; Brass & Bronze, Pattern, Light Metals, Steel, Die Casting and Permanent Molding. A joint luncheon by the Gray, Ductile, and Malleable Divisions.

Six shop courses will be held during the Congress. These are held during the evening so that local foundrymen can attend. The Sand Division will conduct two, the Gray Iron Division will hold two, and one each will be held by the Pattern and Ductile Division.

Much of the strength of the 1961 Castings Congress program comes from authors who have consistently contributed to the program, many of whom are identified with continuing investigations.

Among those who also participated in the 1960 technical program are R. W. Heine, H. W. Dietert, C. K. Donoho, R. W. Flinn, L. H. Van Vlack, A. V. Ayvasian, M. C. Flemings, H. F. Taylor, S. Z. Uram, R. A. Rosenberg, G. J. Vingas, A. H. Zrimsek, M. L. Foster, S. Goldspiel, G. A. Colligan, D. C. Williams, E. H. King, and J. S. Schumacher. Many more have authored numerous papers in the past.

The technical program is supplemented this year by contributions from authors in the aircraft and missile field. Included are W. A. Bailey and E. N. Bossing, Douglas Aircraft Co.; A. J. Iler, Northrup Corp.; R. G. Bassett, Aero-Space Div., Boeing Airplane Co.; and S. A. McCarthy, McDonnell Aircraft Corp.

It's Not All Work at the Congress

As a break in the tempo at the Castings Congress, three barbershop groups will entertain foundrymen and their wives at the Annual Banquet to be held at the Sheraton Palace Hotel in San Francisco.

Host Committees Making Final Arrangements for 65th Congress

Final arrangements are being made by the various groups of the Northern California Chapter's Host Convention Committee. S. D. Russell, Phoenix Iron Works, is chairman of the Host Chapter Committee. John R. Russo, Russo Foundry Equipment Co. is co-chairman, and Davis Taylor, Wheelabrator Corp., is secretary-treasurer. Hugh F. Prior, Superior Electrocast Foundry Co., is Chairman of the Northern California Chapter, host to the 65th Castings Congress.

The committees:

SHOP COURSE—Chairman, Robert A. Johnston, Amador Minerals Co.; co-chairman, M. E. Ginty, Vulcan Foundry Co.; Robert J. Koontz, U. S. Pipe & Foundry Co.; Malcomb R. McGregor, General Metals Corp.; Terry Boscacci, American Brass & Iron Foundry; Kenneth B. Hapgood, H. C. Macaulay Foundry Co.; William R. Skinner, Jr., Atlas Foundry & Mfg. Co.; Jack Donahue, Pacific Foundry & Metallurgy Co.; and Bill Burt, Berkeley Brass Foundry.

PUBLICITY—Chairman, J. M. Snyder, National Abrasives; co-chairman, Harold Henderson, H. C. Macaulay Foundry Co.; Joseph Ternes, Kaiser Steel Corp.; and Robert Evans, Columbia Geneva Div., U. S. Steel Corp.

LADIES ACTIVITIES — Chairman, Clayton Russell, Phoenix Iron Works; co-chairmen, Mrs. S. D. Russell and Mrs. John R. Russo. (See March issue for program).

BANQUET COMMITTEE—Chairman, Lane M. Currie, H. C. Macaulay Foundry Co.; co-chairmen, Vince J. Monte Verda, Amador Minerals Co., and Clayton Russell, Phoenix Iron Works. Others: Don C. Elsener, Columbia Geneva Div., U. S. Steel Corp.; Robert D. Malin, Union Carbide Metals Div., Union Carbide Corp.; James N. Ditmer, Pacific Graphite Co.; James E. Christian, Brumley Donaldson Co.; Burt P. Christensen, Gladding McBean & Co. Others

include: Franklin M. Moses, Wilson & George Meyer & Co.; E. Mack Miller, American Air Filter Co.; Stanley J. Grys, Federated Metals Div., American Smelting & Refining Co.; E. J. Ritelli, General Foundry Service Co.; William F. Quirie, Snow & Gagliani; Leo Eachus, Pinkerton Foundry; and Murray Schmidt, Kaiser Refractories & Chemical Div., Kaiser Aluminum & Chemical Corp.

RECEPTION COMMITTEE—Chairman, Donald C. Caudron, Pacific Brass Foundry of San Francisco; Paul Arnold, U. S. Pipe & Foundry Co.; John Bermingham, E. F. Houghton Co.; William E. Butts, General Metals Corp.; Lane M. Currie, H. C. Macaulay Foundry Co.; Harris M. Donaldson, Brumley-Donaldson Co.; James T. Francis, Micro Metals, Inc.; Stuart N. Greenberg, Sr., M. Greenberg's Sons; William S. Gibbons, Ridge Foundry.

Also: Charles Hoehn, Jr., Superior Electrocast Foundry; Ivan L. Johnson, Pacific Steel Castings Co.; Frank F. Lovett, Vulcan Foundry Co.; Fred A. Mainzer, Pacific Brass Foundry of San Francisco; Gordon Martin, Atlas Foundry & Mfg. Co.; George McDonald, Berry's Foundry; George Rauen, Pacific Foundry & Metallurgy Co.; Philip C. Rodger, Vulcan Steel Foundry; Clayton Russell, Phoenix Iron Works; George W. Stewart, East Bay Brass Foundry; Edward W. Welch, American Manganese Div., American Brake Shoe Co.; and Fred T. Williams, Empire Foundry Co.

PLANT VISITATION—Chairman, Charles R. Marshall, Industrial & Foundry Supply Co., co-chairman, Edward S. Valentine, O. L. King & Co.; Paul L. Arnold, U. S. Pipe & Foundry Co.; James S. Campbell, University of California; Art Ciapponi, Vulcan Steel Foundry; I. E. Denning, Service Pattern & Foundry Co.; John Evonow, Pacific Brass Foundry of San Francisco; Michael A. Furey, Mare Island Naval Shipyard; William S. Gibbons, Ridge Foundry; Raymond W. Haun, San Francisco Iron Foundry; Victor Henderson, H. C. Macaulay Foundry Co.

Also: Harold R. Hirsch, American Manganese Steel Div., American Brake Shoe Co.; Donald L. Mason, Superior Electrocast Foundry; Philip McCaffery, General Metals Corp.; Harold Riskus, American Radiator & Standard Sanitary Corp.; Weldon L. Russell, Phoenix Iron Works; Frederick A. Sanders, M. Greenberg's Sons; Benny L. Smith, Empire Foundry Co.; George W. Stewart, East Bay Brass Foundry; E. S. Taylor, Pacific Steel Castings Co.; Richard Warner, Atlas Foundry & Mfg. Co.; Roy C. Wendelbo, De Sanno Foundry & Machine Co.; and Joe Rogers, American Brass & Iron Foundry.

H. F. Prior

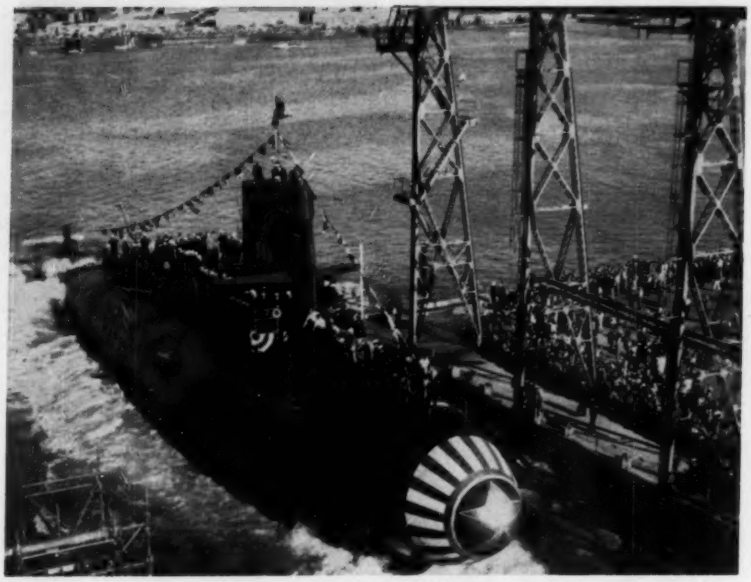
D. L. Caudron

Hotel Headquarters

The Sheraton Palace Hotel will be headquarters for the Castings Congress. Registration, technical sessions, and most events will take place here.

Tentative Schedule of Technical Sessions
65th AFS Castings Congress—May 8-12, 1961—San Francisco

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9:30 to 11:30 am	Brass & Bronze Malleable Pattern	Brass & Bronze Pattern Malleable Light Metals T&RI Trustees	Annual Business Meeting & Hoyt Lecture	Steel Ductile Iron Fundamental Papers Die Casting & Perm. Mold	Sand Ductile Iron Fundamental Papers Steel
12:00 noon		Brass & Bronze Luncheon Pattern Luncheon Board of Directors Meeting	Light Metals R. T. Luncheon Joint Gray Ductile & Malleable Luncheon	Steel Luncheon Die Casting R. T. Luncheon Past Presidents Luncheon	
2:00 to 4:00 pm	Pattern Brass & Bronze Sand Heat Transfer	Light Metals Industrial Engrg. & Cost Gray Iron Sand	Industrial Engrg. & Cost Plant & Plant Equipment Steel	Sand "Symposium on Vacuum Melting & Casting" sponsored by Fundamental Papers Comm. & Steel Division	2:00 to 5:30 pm
4:00 to 5:30 pm	Sand Brass & Bronze SH&AP Malleable Light Metals	Light Metals Gray Iron Malleable	Gray Iron Die Casting & Perm. Mold Sand Steel	Gray Iron Die Casting & Perm. Mold Ductile Iron	
6:00 pm			Annual Banquet	Alumni Dinner	
8:00 to 10:00 pm	Sand Shop Course Pattern Shop Course	Gray Iron Shop Course Sand Shop Course		Gray Iron Shop Course Ductile Iron Shop Course	



Launching of submarine at Mare Island Naval Shipyard. The Yard's foundry is one of many facilities open for inspection on the plant visitation program.

Extensive Plant Visit Program Gives Cross-Section of Area

An extensive plant visitation program, including a visit to the Mare Island Naval Shipyard, is planned for foundrymen attending the 65th Castings Congress.

The Mare Island tour will be held Thursday, May 11, leaving the Sheraton Palace Hotel at 9:00 am, touring the Yard in the morning, and attending a smorgasbord luncheon. In the afternoon a tour will be made of the Yard foundry.

Other foundries indicating participation in the program are:

San Francisco

M. Greenberg's Sons, Inc., a 107-year old firm manufacturing ornamental bronze, valves and fittings.

Pacific Brass Foundry of San Francisco, a jobbing non-ferrous shop specializing in a wide variety of alloys.

San Francisco Iron Foundry, a small gray iron jobbing foundry in downtown San Francisco.

South San Francisco

Superior Electrocast Foundry, small and medium steel castings.

Oakland

American Brass & Iron Foundry, producer of soil pipe and fittings.

American Manganese Steel Div., American Brake Shoe Co., manganese steel castings.

DeSanno Foundry & Machine Co., non-ferrous foundry operated in conjunction with machine shop producing a variety of small parts and fittings.

Empire Foundry, jobbing iron and steel foundry.

General Metals Corp., diesel engines and jobbing iron and steel castings.

Phoenix Iron Works, gray iron, semi-steel, and nickel-chromium castings.

Service Pattern & Foundry Co., small non-ferrous jobbing shop.

Vulcan Steel Foundry, small and medium steel castings.

Berkeley

H. C. Macaulay Foundry Co., iron and ductile castings, producers of the Offenhauser engine block casting.

Pacific Pressure-Cast Products, plaster matchplates and precision castings in ceramic molds.

Pacific Steel Castings Co., small and medium steel castings.

University of California, Engineering Dept., working student foundry with various experimental research and development projects.

Richmond

American Radiator & Standard Sanitary Corp., sanitary castings.

Atlas Foundry & Mfg. Co., gray iron production castings.

East Bay Brass Foundry, green sand, shell, and permanent mold nonferrous castings.

Union City

United States Pipe & Foundry Co., DeLavaud method of centrifugally casting iron pressure pipe.

Vallejo

Mare Island Naval Shipyard, nonferrous, iron, and steel castings.

Top AFS Events During Congress

Not only does the Castings Congress provide the outstanding technical activity of the year, it also furnishes the stage for the most important Society functions.

Wednesday morning is devoted to the Annual Business Meeting. This includes the President's annual address, election of officers and directors, Apprentice Contest awards, and presentation of Awards of Scientific Merit and Service Citations.

Six outstanding foundrymen will be honored for their contributions to the industry and Society at the Business meeting. Awards of Scientific Merit will be given to Harvey E. Henderson, Lynchburg Foundry Co., Lynchburg, Va., Theodore R. Schroeder, Pontiac Motor Div., General Motors Corp., Pontiac, Mich.; and Herbert J. Weber, Director of the AFS Safety, Hygiene & Air Pollution Control Program.

Service Citations will be presented to Alexander D. Barczak, Superior Foundry, Inc., Cleveland, Kenneth M. Smith, Caterpillar Tractor Co., Peoria, Ill., and Jess Toth, Harry W. Dietert Co., Detroit.

The Annual Hoyt Lecture, always one of the features of the Castings Congress will be presented by Jack B. Caine, Cincinnati. He will speak on "Cast Metals and Shapes."

AFS Gold Medals, the highest honor of the Society will be presented at the Annual Banquet. Merton C. Flemings, Jr., assistant Professor of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass., will be given the Peter L. Simpson Gold Medal. William S. Pellini, Metallurgy Department, Naval Research Laboratories, Washington, D. C., will receive the John A. Penton Gold Medal.

Entertainment at the Annual Banquet will be provided by three barbershop groups. These are the "Californians," 1957-58 International Championship Barbershop Chorus, the "Bay City Four," and the "Jazzabelles."

Stadthalle, hall site of various performances, sports events, and festivals in Vienna. In addition to the International Congress, the program includes plant visits, sightseeing tours, social events, and a ladies program.

Vienna Host to International Foundry Congress June 18-24

Austrian foundrymen will be hosts to the 28th International Foundry Congress to be held June 18-24 in Vienna. The Association of Austrian Foundry Experts is making arrangements for the International sponsored by the International Committee of Foundry Technical Associations.

Program details are not available, but all events will take place in the Congress rooms of the Vienna Imperial Castle, former residence of the Austrian emperors.

The daily schedule:

Sunday, June 18—All-day events, Congress Bureau opens.

Monday, June 19—Morning, Congress opens; afternoon, working sessions and city sight-seeing tour; evening, attending a Vienna "Heurigen."

Tuesday, June 20—Morning and afternoon, technical lectures and working sessions.

Wednesday, June 21—All-day events, plant visitations; evening, banquet of official delegates.

Thursday, June 22—Afternoon, technical lectures and working sessions.

Friday, June 23—All-day events, free time for visiting places of artistic and historical interest; evening, banquet and ball.

Saturday, June 24—Closing events.

Division Changes Announced by AFS

The following personnel changes have been made recently within the AFS technical divisions.

Die Casting & Permanent Mold Division—Chairman, R. P. Dunn, Lindberg Fisher Div., Lindberg Engineering Co., Chicago; Vice-Chairman, Nick Sheptak, Dow Metal Products Co., Midland, Mich.; Secretary, A. B. DeRoss, Kaiser Aluminum & Chemical Sales, Inc., Pig & Ingot Dept.

Permanent Mold Process Committee—F. N. Eaton, Zollner Corp., Fort Wayne, Ind., replaces L. W. Wickson, Centr-O-Cast & Engineering Co., Detroit, as chairman.

Heat Transfer Committee—Robert Spear, Alcoa Research Laboratories, Aluminum Co. of America, Cleveland, succeeds W. K. Bock, National Malleable & Steel Castings Co., Cleveland, as chairman.

Record Turnout for T&RI Course

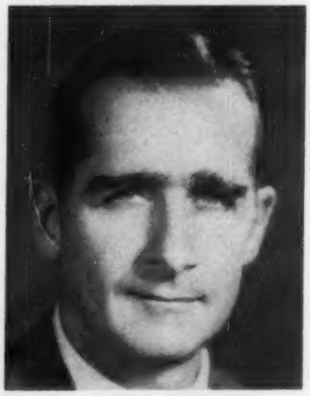
Proof of the increasing enrollment in AFS-T&RI courses was demonstrated by the *Shell Course and Molds* course given March 8-10 in Birmingham, Ala. Sixty-two students attended, the largest number ever to attend a program co-sponsored with an AFS Chapter. The Birmingham Chapter cooperated in its presentation.

Typical case problems brought to the course by foundrymen-students attracted considerable discussion. Actual cases were studied by a panel of industry experts who donated their time as instructors.

Teachers were: O. Jay Myers, Foundry Products Div., Reichhold Chemicals, Inc., White Plains, N. Y.; G. E. Ceebin, National Engineering Co., Chicago; Ray Olson, Southern Precision Pattern Works, Birmingham; John Smillie, Lakey Foundry Corp., Muskegon, Mich.; Larson E. Wile, Lynchburg Foundry Co., Lynchburg, Va.; and AFS Training Supervisor, R. E. Betterley.

Board Names Nevins As AFS Director

M. E. Nevins, president, Wisconsin Centrifugal Foundry, Inc., Waukesha, Wis., and vice-president, Waukesha Smelting Co., has been named as AFS Director by the Society's Board of Directors. He will serve a three-year term, 1961-1964.



Nevins is a 1941 graduate (BS, Metallurgy) of Missouri School of Mines. He worked for Weirton Steel Co. in 1941 as a junior metallurgist, then went to Ampco Metal, Inc., as a foreman trainee, leaving in 1945 to form his own company. He served as President of the Non-Ferrous Founders' Society during 1960.

Sand Committees Report on Status

Investigations covering a wide range of subjects are being conducted by committees of the AFS Sand Division. At a recent meeting of the Executive Committee the groups reported their status.

Molding Methods & Materials—Work completed on preparing the book on MOLDING METHODS AND MATERIALS except for a few contributions.

Programs & Papers—Six technical sessions and two shop courses will be presented at the 1961 Castings Congress. Two foreign papers will be included.

Core Test—Two subcommittees have been appointed to study: 1) tests on furfural binders and 2) cold box binders.

Green Sand Properties—Material will be reviewed developed at the last meeting. A progress report may be possibly presented at the 1962 Castings Congress.

Mold Surface—Surface of test castings made at a working meeting are being measured and will be sectioned and measured microscopically.

Physical Properties of Iron Foundry Molding Materials at Elevated Temperatures—Information has been developed on the incidence of veining but additional control tests will be run to firmly establish the spread in data that can be expected under conditions under which these tests are being made. The work is in progress and more extensive tests will be conducted.

Sand Handbook Revision—Not all portions of the book have been prepared by committees within the division.

Shell Mold & Core—A research program has been developed and materials are being assembled and coated. When completed, the actual experiments will be done by Cowles Technology Laboratory.

Materials Used in Malleable Foundries—From test results it appears that each of the pinholes contained sand grains and several cooperating foundries have agreed to cast additional samples which are being examined.

Controlled Casting Quality—A progress report will be available for the 1961 Castings Congress with a second report scheduled for 1962.

Basic Concepts—The committee is considering void size, void shape, permeability, penetration, and conductivity.

T&RI instructors and students get together informally at ductile iron course. Left to right: Jack Vincent, Mueller Co., Chattanooga, Tenn.; Instructor H. O. Meriwether, Lynchburg Foundry Co., Lynchburg, Va.; Instructor Harold Ruf, Grede Foundries, Inc., Milwaukee.

Also: Instructor T. L. Burkland, Deere & Co., Moline, Ill.; J. H. Jean, Bastian-Blessing Co., Chicago; and Frank Birkhoffer, T. L. Arzt Foundry Co., Chicago.

Training & Research Courses Stress Production, Control

Production and control were strongly emphasized at three AFS Training & Research Institute courses presented in February. Foundrymen from the East Coast to Texas attended the program held in Chicago and Chattanooga, Tenn.

The theoretical is combined with practical problems through a discussion of actual cases submitted by foundrymen-students. Typical problems brought for study at the cupola melting of iron course are gas porosity, excessive chilling, and selection and handling of coke. Cases submitted for recommendations in the sand technology course deal with inclusions both in ferrous and non-ferrous metals. Those attending the sand courses are requested to bring data on their sand mixtures for evaluation.

Questions are answered by a panel of foundry authorities who have donated their time as T&RI instructors.

Cupola Melting of Iron was presented Jan. 30-Feb. 3 in Chicago. Instructors were: Walter R. Jaeschke, Whiting Corp., Harvey, Ill.; Vernon H. Patterson, Vanadium Corp. of America, Chicago; T. E. Barlow, Eastern Clay Products Div., International Minerals & Chemical Corp., Skokie, Ill.; W. W. Levi, consultant, Radford, Va.; AFS Technical Director S. C. Massari; T&RI Training Supervisor R. E. Betterley; and AFS Director of Safety, Hygiene and Air Pollution H. J. Weber.

Sand Control & Technology was held Feb. 13-15 at Chattanooga, Tenn. Instructors were: H. W. Dietert, Harry W. Dietert Co., Detroit; D. C. Rose, Wedron Silica Sand Co., Chicago; Victor Rowell, Archer-Daniels-Midland Co., Cleveland; T. E. Barlow, Eastern Clay Products Dept., International Minerals & Chemical Corp., Skokie, Ill.; and AFS Training Supervisor R. E. Betterley.

Production of Ductile Iron was conducted Feb. 22-24 in Chicago. Instructors were: Eric Welander, John Deere Malleable Works, East Moline, Ill.; Vernon H. Patterson, Vanadium Corp. of America, Chicago; T. L. Burkland, Deere & Co., Moline, Ill.; H. O. Meriwether, Lynchburg Foundry Co., Lynchburg, Va.; Harold W. Ruf, Grede Foundries, Inc., Milwaukee.

No T&RI courses will be held during April. The program resumes May 22-26 with *Core Practices* in Chicago. This course presents concentrated core instruction including the hot box process. It is designed for foremen, sales engineers, supervisors, technicians, engineers, and management. The fee for course No. 8 is $90.

Sand Testing, Course No. 9, $150, will be held June 26-30 in Detroit. The working course involves demonstrations and laboratory work and will be limited to 25 students. *Gating and Risering of Castings*, Course No. 10, $60, will be held July 17-19 in Chicago. The course covers theory and practice.

New Student Chapter

The 14th Student Chapter, and the first to be established in Canada, has been started at the Ryerson Institute of Technology, Toronto, Canada.

Approval for the newest Chapter in the Society has been granted by the AFS Board of Directors.

Foundries Hear Challenge

Speakers Emphasize the Industry Must Re-Evaluate Processes, Opportunities in Preparing for Future

What does the future hold for the foundry industry? More than 900 foundrymen attended two of the oldest regional foundry conferences to hear the answers. At both the Wisconsin Conference and the Southeastern Regional Conference the answers were the same.

In the coming months the industry and the general economy is expected to make a slow but gradual recovery. In both sections, foundries operating at or near capacity are in the minority. Most foundries regardless of their size or metal poured are well below capacity. Order backlogs have been worked off and current production in general is for immediate business.

In a MODERN CASTINGS survey most foundrymen reported that business is approximately where it was six months ago—off 40 to 50 per cent of capacity. One major difference is that operators are not necessarily pessimistic and are better adjusted to the present conditions.

Said one superintendent of a large captive shop, "Six months ago we were producing for inventory, hoping that the decline would be for a short duration. Now our inventories have been fully stocked. We have had personnel layoffs and business hasn't improved. However, we are a lot more realistic about the situation and can live with it."

Near-Record Attendances

One manager of a jobbing shop put it this way, "Business is bad with some price cutting going on. Orders that were steady aren't coming through. We have had to curtail operations and are just making a profit but are keeping our heads out of water. Maybe we will never work seven days a week again. I think that we are kidding ourselves if we think that anything short of a seven day week is a poor condition."

Patternmakers, first in line in the casting process, report operations are more curtailed than foundries. Reports one, "We have never scurried for business as we are now. Business just isn't there at the present time but we are getting some inquiries."

Near record attendance at the two conferences prove that alert foundrymen are using the lull for a re-examination of their role in the metal fabrication market, both in the United States and abroad.

They are assured of a bright future which must entail stricter observance of quality control, better marketing and customer relations, and diversification. They were warned that increased competition within and outside of the industry would eliminate metalcasters not able to keep pace with changing customer demands.

Speakers constantly stressed that the future of metalcastings lies within the foundry industry itself, that united efforts on an comprehensive basis would do much to promote the increased use and acceptance of castings.

Stress Research, Reliability at 24th Wisconsin Regional

Unlimited market opportunities for all phases of the industry was the message of Jack H. Schaum, editor, MODERN CASTINGS. How these opportunities can be obtained were explained by more than 20 other speakers at the Wisconsin ferrous, non-ferrous, steel, gray iron, and patternmaking sessions.

Schaum linked the future of the industry to research and development of new markets. Competitors are extremely active in product development, he warned. "Your only choice is to improve your competitive position by applying new technology, and for that matter, a lot of old technology that has passed your attention. Aggressive foundrymen can only stay competitive in quality and price by making the casting process the shortest, fastest, and most direct path between raw material and finished product."

He observed that eight years lapse from the time that research starts on a new material or process until it reaches commercial application. "You are already eight years behind competitive materials and processes if you start researching today," he stated.

Much of the industry's troubles can be traced to the small amount of money devoted to research on new products, Schaum explained. He credited the industry's vendors for past developments but observed that foundrymen themselves must seek new ways to improve operations, seeking assistance from suppliers.

Each of the major segments of the industry were reviewed and numerous market opportunities listed for future development.

High reliability is a new standard that is necessary for any organization if it is to remain competitive in times of complexity of design and a growing number of parts in ultimate products, remarked C. E. Drury, director of reliability, Central Foundry Div., General Motors Corp.

The new standard must be developed, said Drury, because of the high cost of poor workmanship and the cost of dissatisfied customers. He added that the term encompasses the entire area from design concept to wear out. Each foundry must concern itself with:

1) Part design in regard to compatibility to foundry process.

2) Material and heat treatment specification in regard to the design meeting its functional specification.

3) The entire process of purchasing and receiving material, melting, casting, heat treating, finishing, and final inspection.

Drury conducted an experiment used at General Motors to emphasize the relationship that each process has with others and to highlight the importance of reliability. Each of 10 boxes contained 10, holed-blocks. Nine white blocks represented acceptable parts. One red block indicated a defective part. Ten persons blindly drew one block from each of the 10 boxes and assembled them on a stick.

Despite the fact that only 10 per cent of the blocks in each box were defective, only 40 per cent of the ten assembled sticks contained no defective parts. Mathematically on a 90 per cent quality level, 38 good assemblies out of 100 would be the average result.

Furfural cores, one of the new

Howard Voit, Sterling National Industries Co., Wisconsin Regional Co-Chairman, and Bill Gove, luncheon speaker.—by Bob DeBroux

major developments, received considerable attention. Ray Sutter, Sutter Products Co., discussed *The Advancement of Hot Core Boxes, and What's Ahead for the Soaring 60's.* H. R. Bilter, International Harvester Co., spoke on *Heated Core Box Equipment—What it Means to the Patternshop.* The subject was frequently mentioned also in other technical sessions.

Sutter stated the advantage of furfural cores include: less scrap, higher production, and improved finish. Although used largely in automotive foundries at present, Sutter predicted many applications, particularly in high production shops. He emphasized that success of the hot box process is greatly increased when patterns and core boxes are designed to suit the operations.

Bilter stressed hot core box equipment and maintenance and told of Harvester's evaluation of the furfural process. (See MODERN CASTINGS, January, page 31 for complete details on Harvester's use of the furfural process).

Aero-Space Applications

Aero-space industries represent an excellent market for castings, according to John Varga, Battelle Memorial Institute. This is true despite the relatively poor acceptance of castings to date.

Three factors have contributed to the small number of castings used:

1) Design engineers do not understand foundry abilities and processes.

2) Castings have often been used as a last resort and required to conform to designs originally intended for other processes.

3) Foundries have lacked an appreciation of the necessity for quality control in the aero-space industry.

Varga detects a growing change in the attitude toward castings. One reason is an effort to acquaint designers with foundry practices. Another is a more practical approach on aircraft-missile standards. A third is the willingness of foundries to learn the requirement and objectives of the aero-space industry.

That the aircraft-missile industry represents a great potential was emphasized by Roy J. Handwerk, B. F. Goodrich Chemical Co. Div., B. F. Goodrich Co., in discussing *What A Foundry Can Expect with a Plastic Core Binder.*

Said Handwerk, "Because of a lack of quality, aircraft manufacturers relegate castings to hardware items—parts which serve a function but carry no working load."

"Structural parts are produced by more expensive fabrication methods, which represent a good market for castings, but a market that is being missed because of quality," he commented.

Stress Quality

Quality of castings was again stressed by Edward J. Wellauer, Falk Corp., who spoke on *Machinability of Steel Castings.* He stated that special excellence is essential today to meet customer demands. Machinability ranks high in this respect. Wellauer discussed machinability as related to heat treatment, deoxidation of steel, non-metallic inclusions, sand and other defects, metallographic structure, leaded and sulfurized steels, and hardness.

Indications of how foundry technology is provided by industry vendors was provided by C. R. Howle, Aluminum Co. of America, in speaking on *"What's New in Light Metals?"*

Much of the Wisconsin Regional technical program was devoted to current developments and production problems.

"A concentrated team effort will solve most foundry problems," said Albert Steck, Wehr Steel Co., in his talk on *Producing High Quality Non-Ferrous Castings Economically.* His recommendations included the forming of a good team, leadership for motivation, and checking the amount of time needed to produce a quality casting. New methods, materials, and processes must be investigated to see if they can produce the casting more economically, he advised.

Recent innovations in steel molding was presented by Lester B. Knight, Lester B. Knight & Associates, and Prof. R. W. Heine, University of Wisconsin. Knight stressed the importance of concentrating on work best suited to the plant and manpower available, adhering closely to standard practice procedures. He stated that while the United States has superior raw materials, the people of other countries obtain good quality and economy through attention to details.

Wisconsin Regional Conference Chairman, L. S. Krueger, Pelton Steel Casting Co., points out a program highlight to Dr. J. Shea, AC Sparkplug Co., banquet speaker.—by Bob DeBroux

Heine stated that the future might bring innovations such as stabilized silica, improved mold coatings, and new sand additives. However, he emphasized, for the present the better use of known materials is the most important.

Ten years of successful melting of malleable iron by low induction furnaces was explained by Charles F. Smith, I-F Mfg. Co. Benefits include

controlled analysis and the ability to operate 24 hours a day with continuous metal supply. Operations, maintenance, and advantages of the process were shown through slides.

Controls Pay Dividends

Close control of all variables and operating conditions will pay big dividends, many speakers asserted. Don Dalton, Thiem Products Co., said that with the emphasis on production, fundamentals of good sand practice techniques must not be overlooked. He advocated getting good control of materials by reducing variables to a minimum. Dalton also recommended measuring by weight not volume, close control of sand by grain distribution, use of dry sands, and equipment maintenance. He said that core coatings are important but they can not make a bad core good.

Marvin Evans, consulting metallurgist, discussed the heat treating of cast iron. Uniformity of temperatures in heat treating ovens and furnaces was stressed as being highly important. He also discussed control of physical properties through heat treatment, emphasizing that customer requirements are making control of physical properties increasingly important.

Progress in new core development lies in the field of synthetics, said Edward F. Koglin, G. E. Smith, Inc., who discussed the cold set and the newer cold cure processes for jobbing shops and the furfural cores for high production shops.

Warning to Patternmakers

New developments in plastics and patterns were covered by Stan Munson, Ren Plastics, Inc., and R. J. Christensen, Wisconsin Pattern Work Inc. In explaining the Shaw process Christensen warned patternmakers that toolrooms are taking over much of the pattern business. Further business will be lost, said Christensen, if the patternmaking industry does not keep pace with technical developments.

Use of exothermics on malleable iron were discussed by Jack W. Giddens, Foundry Services, Inc., who outlined their advantages. Latest developments in pyrometry were covered by Douglas Johnston, Barber Coleman Co. Allan Goldblatt, Applied Research Corp., dealt with foundry control of all elements in cast iron with the quantovac. Foundry flexibility through automation was explained in a film by Carl Schopp, Link-Belt Co.

A major change in cupola operation, the injection of materials into the melting zone was seen as a possibility by George Anselman, Anselman Foundry Services, in his talk on *Pneumatic Chip Injection by the Roxy Process.*

Other speakers were AFS Regional Vice-President H. M. Patton who spoke on the future of AFS and Dean Wendt, University of Wisconsin, who alerted foundrymen to the fact that new materials are now being created with unusual properties as the result of applying new theories developed in solid state physics.

Lawrence S. Krueger, Pelton Steel Casting Co., served as conference chairman assisted by co-chairmen Prof. P. C. Rosenthal, University of Wisconsin, Howard Voit, Sterling National Industries, and Richard Ballmann, General Castings Corp.

Emphasize Production Techniques at 29th Southeast Regional

Production techniques for improving quality and cutting costs, improved worker environment, and accurate accounting procedures were emphasized at the Southeastern Regional Foundry Conference.

Speakers presented their solutions to how foundries can maintain and increase their share of the metal fabrication market. Purity of metal, quality of castings, and close attention to details were listed as the goals, either present or future.

A picture of what the foundry 25 years from today may look like was painted by C. A. Sanders, American Colloid Co. In large part, Sanders' prediction for the future was based on equipment and practices he had observed in European metalcasting plants. Increasing competition from low-cost, high-quality European castings was seen by Sanders.

Among the equipment and processes likely to be a part of the foundry of tomorrow are: an increasing use of electronics, composite patterns, vacuum melting and alloying, new shakeout and pouring equipment, and improved gating practices.

Said Sanders, "It is our opinion that the foundry will eventually replace 70 per cent or better of all present machining operations and the foundry will simply be a tool to cast, clean, and perhaps grind surface areas ready for final assembly."

Immediate problems facing foundries were tackled by succeeding speakers who outlined programs ranging from improved metal melting to plant safety.

Improved cupola operations were detailed by H. W. Schwengel, Modern Equipment Co., and W. W. Levi, consultant. Advantages of water-cooled cupolas were listed by Schwengel as decreased cost for refractory and maintenance, extension of melting over prolonged periods of time, and superior flexibility and control.

The water-cooled cupola was defined as a liningless, externally water-cooled shell with protruding water-cooled tuyeres and a neutral refractory in the well. The construction, explained Schwengel, as well as the type of refractory, makes it a neutral melting vessel that can be operated with a basic, acidic, or neutral slag in keeping with the flux materials charged.

Its greatest advantage, pointed out Schwengel, is the flexibility it possesses through the use of controlled slag, making possible substitutions over a wide range of materials.

Good carbon control is essential to quality control, emphasized Levi. "In most ordinary irons, carbon is the most important element, having three times as much influence on the physical and mechanical properties of the metal in the castings as does either silicon or phosphorous," Levi emphasized to ferrous foundrymen.

He pointed out that the percentages of silicon and phosphorus in the iron at the cupola spout have an important bearing on carbon pick-up during melting. He observed, "In order to make a reasonably close estimate of the carbon at the spout, the percentages of silicon and phosphorus and the carbon percentage must be known. This requires a knowledge of the composition of the metallic components in the charge. Once the cupola charge has been calculated, each component must be carefully weighed on equipment which is sensitive over the range in which it is to be used."

Aluminum risering, feeding, and degassing were covered by Donald Wyman, Exomet, Inc. He rated the degassing techniques in order of ef-

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fectiveness as chlorine, solid compounds, and nitrogen. Wyman also spoke on the grain refining ability of titanium, boron, and a combination of the two. He explained how insulated risers promote solidification and allow use of fewer and smaller risers.

Cutting Production Costs

Core and mold blowing equipment was the subject of a talk by Lawrence Pridmore, International Molding Machine Co. Two points constantly stressed were the importance of proper venting, and size and location of blow holes. Pridmore explained that without vents, a core box acts like a cylinder. He briefed foundrymen on mold blowing or flask filling, in which critical portions are blown and the remainder of the flask filled with sand and then squeezed. He observed that many machines can be converted to core blowing regardless of their age or the materials to be blown.

Production savings combined with sand uniformity are available through sand reclamation, C. T. Jones, National Engineering Co., told Southeastern foundrymen. Of the three reclamation types, thermal, wet, and pneumatic, Jones recommended the pneumatic unit.

Lack of understanding as to the role of sand reclamation has prevented more universal use, he stated. Jones defined the process as "Performing work on individual waste sand grains in such a manner as to return the grain surfaces to a condition where they will perform as satisfactorily as, or better than, new sand in subsequent molding or coremaking functions."

Through slides Jones showed how the original sand grain undergoes changes in size, appearance, and characteristics through additions and processing. Use of reclaiming units strip sand grains of clay coatings, carbonaceous and vitrified clay coatings, and combustibles.

Properly applied reclaiming equipment has in some instances resulted in a 67 per cent reduction in new sand usage, indication a considerable available savings in new sand purchases. Jones pointed out that sand reclamation is not a mysterious new variable to be avoided, but a simple, useful foundry tool for cutting foundry operating costs.

Attention to details and an understanding of snagging and cutoff principles will return big dividends to foundrymen, promised J. A. Mueller, Carborundum Co. These savings are based on the selection of the proper wheel to do the job and using it at the most efficient speeds and feeds.

He emphasized that grinding wheel costs can be reduced through the use of faster cutting but shorter lived grinding wheels. A critical study of published data and individual foundry grinding operations were recommended as a means of lowering total casting costs.

How can U. S. foundrymen compete with other methods of metal fabrication and the growing threat of foreign competition based on cheap labor? Through new technology and improvement of current practices, said Harry Kessler, Meehanite Metals Corp. Even more important, pointed out Kessler, is a quick, accurate cost program. Five elements were listed as needed for determining foundry costs. These are:

1) Labor costs including direct, indirect, supervisory and foundry.

2) Indirect materials costs including metals costs (less the credit for returns), fuel and ferro alloys costs.

3) Indirect materials cost including foundry and maintenance supplies.

4) Factory overhead including depreciation, plant rent, equipment rent, loss on returned castings, salvage costs, heat, power, air, water, freight and express, insurance, professional engineering, telephone and telegraph, property taxes.

5) General and (sales) administrative overhead costs.

Effective Cost System

Kessler pointed out that the variable costs are labor and overhead. The fixed costs are direct and indirect materials. By maintaining the tonnages, overhead costs remain constant; by controlling the labor hours per ton of good castings, labor remains constant; and with a fixed cost per pound of materials (direct and indirect), the costs do not vary.

The problem facing metalcasters, said Kessler, is to change manufacturing methods to offset the increase in labor costs and try to maintain the volume or reduce the overheads in a falling tonnage market.

New developments in green sand molding were detailed by T. E. Barlow, Eastern Clay Products Dept., International Minerals & Chemical Corp. Said Barlow, "The big change in green sand molding has been the recognition of the extreme value of the elimination of mold wall movement to produce castings which are close to dimension and free of defects."

He pointed out that not only are customers satisfied but foundries benefit through lower casting losses and increased yield coming from the reduction of riser systems and lower scrap. For that reason strengths have been operated at a higher level and the special additives are involved for permitting these higher levels. The additives were described in detail to show the effect of each on the various properties.

Said Barlow, "Popular practice today might describe a moderate strength of 14 to 16 pounds and high strengths over 18 pounds. There are more and more foundries running green strengths in the high range and fewer and fewer running in the range of weak sands of 8 and 10 pounds. Only strong sands are capable of producing high mold densities and, therefore, castings which are close to tolerances and size.

A good portion of the talk was devoted to describing the reaction of each additive when introduced into a system of different clay base. It was pointed out that these additives did not have a generic effect but rather had an effect which was in a direct function of the clay being used. For example, it was observed that the fire clay bond sand reacted entirely different to the addition of cereal and wood flour than did the western and southern bentonite sands.

Important savings may be had by foundrymen through proper use of ventilation, said H. J. Weber, AFS Director of Safety, Hygiene and Air Pollution. Weber discussed mistakes frequently made by foundries which invariably prove to be expensive.

Some of the principal mistakes are:

1) Failure to introduce air to replace the amount exhausted. This makes the operation of the ventilation system more and more ineffective as the vacuum in the plant increases.

2) Failure to recognize that air short circuits in the same way that electricity does. It will follow the path of least resistance. Roof ventilators have no effect at floor level when monitor windows are open.

3) Failure to realize the difference in the behavior of air when it is blown and when it is exhausted.

4) Failure to realize that the velocity of air decreases as the square of the distance from the source of the suction. This means that a suction opening must be very close to the source of any air contaminant.

Herman Bohr, Jr., served as the general conference chairman with Ernest E. Finch as co-chairman. J. L. Payne was program chairman and Frank Robbins, Jr., was co-chairman. The conference was sponsored by the Tennessee, Birmingham, and University of Alabama Student Chapters.

CHAPTER NEWS

Northeastern Ohio Chapter Sponsors Extensive Symposium on Sand Topics

An extensive, four-session sand symposium ranging from sand testing to the new furan binders has been recently completed by the Northeastern Ohio Chapter. One session was held at the Manger Hotel, the remaining three at Case Institute of Technology.

Unbonded Molding Sand and Clay Bonds were discussed by Prof. Willis G. Lawrence, Alfred University, Alfred, N. Y. Ordinary molding sand is a combination of sand aggregate, inorganic bonding agent, and water, Lawrence stated. He outlined the constitution of bentonites and explained how small amounts of water are adsorbed to the surface of the clay particles, forming strong but brittle films.

Above one per cent, but below a certain limit, additional water fills voids between grains to give plasticity. Other properties of clay bonds affected by water content are dry strength, wet strength, and swelling volume.

Mulling and Compacting Molding Sands were outlined by Prof. R. W Heine, University of Wisconsin, Madison, Wis. He pointed out that mulling is the mixing of ingredients and coating of sand grains but that it is also agglomeration and attrition. Correct mulling is a balanced mixture of agglomeration and attrition.

Heine stated that a good mold has a bulk density of 90-95 pounds per cubic foot, good mold hardness, and is faithful to the pattern. Magazine molding–filling molds by air pressure followed by a light squeeze –was suggested by Heine to be the molding method of the future.

Oil-Bonded and Shell Cores, was presented by Edward C. Zuppann, Lakeshore Div., Bendix Corp., St. Joseph, Mich. He described jolt overhang and jolt sag tests which were used to evaluate various mixes of cereal, core oil, and other coremaking ingredients. Each cereal tested had a moisture level for maximum overhang strength and sag resistance. Southern bentonite was found to be the best clay to add for increased sag resistance.

For shell molding, Zuppann suggested using the coarsest grain size that will satisfy finish requirements. Most shell core resins are thermoplastic during coating and are converted chemically to thermosetting resins so that they will harden as cores are cured. Sand can be cold coated by dissolving materials in alcohol and water, mixing with sand, and evaporating the solvents, or hot coating can be carried out at 300-350 F. Cold coating is simpler but uses more costly ingredients.

CO_2 Process and Furan Cores were discussed by Robert J. Mulligan, Federal Foundry Supply Div., Archer-Daniels-Midland Co., Cleveland. He strongly recommended selection of the proper process rather than fitting a job to the process. Advantages of both processes as well as operating techniques.

Be Your Own Sand Detective by Joseph Schumacher, Hill & Griffith Co., Cincinnati, dealt with the application of sand testing to foundry operations. He pointed out that the big problem is the proper interpretation of data. Clay testing is best accomplished by the newly developed effective clay test. From a standardized plot and data on green compressive strength and shear strength, effective clay can be determined. Other important tests are volatile carbon content analysis,dry compression test, and mold hardness test. A minimum pressure of 40 psi should be exerted over the mold surface and 50 psi is preferred.–by Wallace D. Huskonen

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BRITISH COLUMBIA—Conventional and new core processes were explained by R. J. Mulligan, Archer-Daniels-Midland Co., left. On right is former Chapter Chairman Jim Hornby, Balfour Guthrie Co.—by J. G. Smith

NORTHWESTERN PENNSYLVANIA—One of the youngest AFS members, F. B. Bueg, Arrow Castings Co., serves as the official chapter greeter.—by Walter Napp

BRITISH COLUMBIA—Brian Travis, left, is presented with the AFS PATTERNMAKERS' MANUAL by Chapter Chairman Henry Bromley. Travis also received a one year's membership in AFS upon his completion of his apprenticeship.—J. G. Smith

CHICAGO—Speaker W. D. Chadwick ininspects projection equipment prior to talk. —by George DiSylvestro

TENNESSEE—Improving castings through sand practice was explained by W. A. Hambley, Krause Milling Co., center. Others are Chairman Thomas A. Deakins and Vice-Chairman James L. Payne.—by John D. Kling

Rochester Chapter
Holds Joint Meeting

Weapons and weapon systems under development for the national defense were outlined at a meeting with the American Society of Metals and the Production Supervisors' Group of the Industrial Management Council.

John H. Garrett, chief of the Material Div., Office of the Director of Defense Research and Engineering, analyzed the materials problems faced by designers and production personnel. Prime functions of organizations working on material problems were indicated.—by Haerle Wesgate.

Tri-State Chapter
Uniform Casting Quality

Each foundry should develop a casting engineer from within its company to head up an effective quality control program, advised R. H. Jacoby, St. Louis Coke & Foundry Supply Co., St. Louis.

Clear, accurate records are essential in each department, he stressed. He also recommended that a training program be developed for each department.—by Bobby Bell

PIEDMONT—A sand demonstration was held at a recent chapter meeting. The group with 138 members had an attendance of 138. Shown are: Donald Kling, Ross-Meehan Foundries, Chattanooga, Tenn.; Prof. Couch, Clemson College; William Cosby, Glamorgan Pipe & Foundry Co., Lynchburg, Va.; Dixon Brook, DeBardeleben Coal Corp., Birmingham, Ala.; and Robert Blakely, Sloss Pig Iron Div., U.S. Pipe & Foundry Co., Birmingham. Plant visits were made to Lynchburg Foundry and Glamorgan Pipe & Foundry.—by Larson E. Wile

NORTHWESTERN PENNSYLVANIA—Mechanization and modernization of foundries was explained by L. B. Knight, Lester B. Knight & Associates, Chicago, right. Others are Chairman W. J. Miller and Vice-Chairman C. H. Bendig.—by Walter Napp

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NORTHWESTERN PENNSYLVANIA—Visitors at a recent meeting included G. V. Cruickshank, Pittsburgh Chapter; G. E. Goetsch, Western New York; and Northeastern Ohio Chapter Chairman N. J. Stickney.—by Walter Napp

PITTSBURGH—Chapter officers: Secretary-Treasurer, E. P. Buchanan; Vice-President C. E. Peterson; and President W. D. Hacker.—by Walter Napp

SOUTHERN CALIFORNIA—How welding can be profitably used in foundries other than for salvage were outlined by J. Marden, Eutectic Welding Alloys Co., center. Others: Chairman C. F. Weisgerber and Program Chairman A. Tuzzolino.—by R. V. Grogan

PIEDMONT—T. E. Barlow, Eastern Clay Products Dept., International Minerals & Chemical Corp., Skokie, Ill., right, receives congratulations from Chapter Chairman Rickford Hanner.—by Larson E. Wile

ONTARIO—Quality control and the foundry industry were explained by W. Moggridge, Canada Iron Foundries, Ltd., left, and D. L. Watson, Galt Brass Co., center. P. Goodwillie, American Standard Products (Canada) Ltd., served as technical chairman.—by E. J. Skelly

PHILADELPHIA — Modern cleaning techniques were discussed by Ralph Lash, Lebanon Steel Foundry Co., center. Others are Chapter Chairman R. C. Stokes and Technical Chairman Harold L. Kurtz.—by Leo Houser and E. C. Klank

Metropolitan Chapter

Preventive Maintenance

A maintenance program producing profits was explained by C. E. Fausel, Chicago Foundry Co. Included in the plan were:

Plotting of trends through complete records on lubrication, life of replacement parts and work performed. Lubrication of all equipment was coded on file cards so that greasers had essential information easily available.

Electricians kept track of the amperage on all equipment. Increases in current requirements led to a complete machine inspection to determine the cause—often eliminating extensive repairs.

The expected life of replacement parts was predicted on the basis of past performance with substitutions made on schedule even though in apparent good working order.—by Charles Muller

Twin City Chapter

Aluminum Gating Practices

Much trouble with feeding and gating aluminum castings originates with the ease in which aluminum forms oxides, G. Leslie Armstrong, U.S. Reduction Co., pointed out.

When this oxide has formed it is extremely difficult to separate it from the clean metal, he said. Another problem pointed out was hydrogen pick up which can come from the water of crystallization in various materials.

Good gating practice is essential because of the 5-7 per cent contraction on solidification and the low density of the aluminum alloys, said the speaker. He recommended runners in the drag and gates in the cope, runner extensions and tapered sprues and wells.—by Matt Granlund

Twin City Chapter

Cupolas and Refractories

Loss or wear in cupola linings is due to chemical, mechanical, and thermal factors, said T. E. Barlow, Eastern Clay Products Dept., International Minerals & Chemical Corp., Skokie, Ill. The primary factor, he pointed out, was the limestone in the charge chemically dissolving the lining.

Mechanical wearing of the lining is due by the blast moving the finer particles upward and outward, he pointed out. "The lining does not burn out but an increase in temperature accelerates the chemical and mechanical factors," he stated.—by Matt Granlund

PITTSBURGH—Electric furnace for steel casting was talk by S. F. Carter, American Cast Iron Pipe Co., Birmingham, Ala., left. On right is discussion leader I. W. Sharp, Walworth Co.—by Walter Napp

CENTRAL NEW YORK—How cereal binders may be used advantageously in foundry operations were explained by David Longueville, Corn Products Sales Corp., right. On left is Technical Chairman James Oschner, Crouse-Hinds Co.—by Anthony T. Izzo

WESTERN MICHIGAN—Attending a recent meeting were AFS Regional Vice-President D. W. Boyd, Engineering Castings, Inc., Marshall, Mich.; Chapter Chairman W. A. Blackmer, Muskegon Piston Ring Co., Sparta, Mich.; and AFS Director Nominee C. J. Lonnee, Alloyed Gairon Castings Corp., Ravenna, Mich.—by J. L. Brooks

CHICAGO—Attending the annual ladies night as guests were former AFS President Frank Shipley and his wife from Peoria, Ill.

CHICAGO—Relaxing at the annual ladies night were Chapter Reporter George DiSylvestro and his wife.

CENTRAL ILLINOIS—The theory that water is the actual binder, not clay, was advanced by C. E. Wenninger, Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago. He predicted that it is possible that molds may be made of sand, clay, and water only. Bentonites, fireclay and their reactions with water were explained from a scientific standpoint. —by Charles W. Search

NEW ENGLAND—The importance of gray iron castings in the American machine tool industry was explained by James Meehan, right. Others are Chapter President P. C. Smith, General Electric Co.; S. J. Gay, Connecticut Coke Co.; and Chapter Vice-President L. W. Greenslade.—by J. H. Orrok

Texas Chapter

Careers in Metalcasting

Because of the nature of the foundry industry and the critical demands made upon its cast production, every day brings new challenges and new opportunities to make a better product in a better way. These provide challenges which many young engineers seek, said W. C. Jeffery, McWane Cast Iron Pipe Co., Birmingham, Ala., in addressing foundrymen and students from Texas A & M Student Chapter.

Six considerations were recommended by Jeffery for students in evaluating careers. What the foundry industry has to offer in each was outlined by the speaker.

To what degree will the work be interesting, challenging, and satisfactory? Said Jeffery, "The cast metals industry provides a variety of career opportunities in such fields as production, research, design, product development, and sales."

What opportunities will I have to further my abilities? To this Jeffery pointed out the industry's advances during the past 20 years.

What are the opportunities for advancement? In answer, Jeffery cited examples of students who have assumed positions of responsibility in relatively short time.

What salary will I be paid now? What salary potentials are possible in the company in the future? Said Jeffery, "Because there are so many opportunities in the foundry industry, the new engineers who prove their capacity and capabilities seem to move faster up the ladder to management responsibilities in the cast metals industry."

Where will I be located? Where are the possible geographic locations in the future? Commented Jeffery, "Although there are areas of industry concentration, every state in the union has some foundry activity. You need not move from one area of the country to another to take advantages of the excellent opportunities in cast metals."

What effort does the company exert to establish and maintain a professional climate? Jeffery outlined the history and purpose of Foundry Educational Foundation and contributions from other professional groups such as AFS.—by C. Eugene Silver

Michiana Chapter

Conducts Split Sessions

How to produce sound brass castings and operating recommendations for cupolas were presented recently by F. L. Riddell, H. Kramer & Co., and E. C. Mathis, Pickands Mather & Co.

Riddell discussed the physical properties of several brasses and the effects of different contaminants. Slides were used to stress the importance of strict metallurgical control.

Mathis observed that much remains to be learned cn cupola operation but recommended a blend of the theoretical and practical observations. In discussing combustion relations in a deep coke bed, he stated that gases whip up through the cupola at approximately 60 miles per hour. He emphasized that combustibility refers to two reactions. The first is the reaction of oxygen on carbon; the second is the reaction of carbon dioxide on carbon. For each per cent of carbon dioxide, there is a fixed amount of carbon monoxide formed.

It it is much easier to loose a coke bed with an underblast than with an overblast, stated the speaker.

Mathis described charging devices and various methods of putting the material into the cupola.—by Joe Lazzara

San Antonio Section

Gating and Risering

Principles of gating and risering were discussed by a three-man panel. Participating were Ed Pruske, Alamo Iron Works, Dennis Yell, S. A. Machine & Supply Co., and Harold Fraunhofer, K. O. Steel Castings, Inc.

Various examples were shown of how foundries differ in gating and risering techniques.

At the previous meeting, Jim Reedy, Hill & Griffith Co., outlined coreroom practices including shell cores, hard baked cores, CO_2 cores, and certain applications where collapsible cores are essential.—by Frank Page

Tri-State Chapter

Non-Ferrous Practices

A continual effort to produce increasingly improved castings must be the goal of all foundrymen, stated Jack Dee, Dee Brass Foundry, Houston, Texas, and AFS Regional Vice-President.

Small foundries must not be satisfied with reasonably good castings, said Dee. He emphasized that no foundry can progress without experiments and research and that quality control must be applied by foundries regardless of size. Pattern equipment and pouring for both shell and green sand were also discussed.—by Bobby Bell

TRI-STATE—Chapter Vice-Chairman Frank M. Scaggs, left, listens to R. H. Jacoby, St. Louis Coke & Foundry Supply Co., elaborate on the principles of uniform casting quality.—by Bobby Bell

TEXAS—Career opportunities in the cast metals industry were outlined by AFS Director W. C. Jeffery, McWane Cast Iron Pipe Co., Birmingham, Ala., to a joint meeting with students from Texas A & M. Shown are: Texas Chapter Chairman E. A. Schlotzhauer, Jr.; Thomas Gabriel, instructor, workshop practice, University of Ceylon; Texas A & M Student Chapter Chairman B. F. Gallagher; Dr. Simmane, head of Mechanical Engineering Dept., Texas A & M; and speaker Jeffery.—by C. Eugene Silver

ST. LOUIS—Use of exothermics was explained at a recent meeting by H. Paul Stephenson, Pittsburgh Metals Purifying Co., Mars, Pa., left. On right is Technical Chairman A. Litzau, Carondelet Foundry.—by W. E. Fecht

Canton Chapter

Conducts Panel Program

Foundry practices were discussed at a recent meeting by a four-man panel. Centrifugal casting as practiced at Shenango Furnace Co., Dover, Ohio, was discussed by Walter Smith. Use of the cold set process was explained by Pat Morgan, Babcock & Wilcox Co., Barberton, Ohio; patternshop practices were examined by Carl Stansberger, Massilon Steel Casting Co., Massilon, Ohio; and use of the Taccone molding machine was described by Mike Wolf, Rockwell Mfg. Co., Barterton, Ohio.

Jerry Hathaway, Massilon Steel Casting Co., served as moderator for the program which attracted 127 foundrymen.—by Charles Stroup

Southern California Chapter

Choosing the Right Core Process

The greatest problems that come to foundrymen is not through the use of the new processes, but rather through their misuse, stated R. J. Mulligan, Archer-Daniels-Midland Co., Cleveland.

He advised foundrymen, in analyzing their jobs, to make the method fit the job. "Don't get caught in the trap of making the job fit the method; this happens more often than many of us are willing to admit," said Mulligan.

"To avoid this pitfall, you first of all have to know what must be accomplished in the terms of production rate, dimensional accuracy, surface finish, detailing, production limitations such as oven capacity, type of metal to be cast, the equipment to be used and its condition, and a myriad of other factors. You then must choose the method that will accomplish these goals within these limitations in the least possible time," he concluded.

Nearly 300 foundrymen attended the meeting.—R. V. Gorgan

AFS Chapter Meetings

APRIL 11-MAY 10

Birmingham District . . April 14 . . Thomas Jefferson Hotel, Birmingham, Ala. . . T. E. Barlow, Eastern Clay Products, *"Cupola Practice."*

British Columbia . . April 21 . . Lougheed Hotel, Vancouver, B. C. . . Prof. W. M. Miller, University of Washington, *"Hydraulics of Gating Systems."* **April 28** . . Admiral Hotel, Vancouver, B. C., *Annual Meeting and Dance.*

Central Illinois . . May 1 . . Vonachen's Junction, Peoria, Ill. . . C. R. Baker, Albion Malleable Iron Co., *"Evaluation of Shell Molding Capability."*

Central Indiana . . May 1 . . Athenaeum Club, Indianapolis . . J. F. Wallace, Case Institute of Technology, *"Gating and Risering."*

Central Ohio . . May 1 . . Seneca Hotel, Columbus, Ohio . . J. Smith, Aluminum Company of America, *"The Aluminum Engine Lightens The Weight."* Past Chairmen's Night and Regional Vice President's Night.

Chesapeake . . April 28 . . Baltimore Engineers Club, Baltimore, Md. . . D. Matthieu, Wysong & Miles Co., *"Castings versus Other Methods of Manufacturing."*

Chicago . . May 1 . . Chicago Bar Association, *General Meeting.*

Connecticut . . April 21 . . Waverly Inn, Cheshire, Conn., *"Ladies' Night."*

Detroit . . April 20 . . Wolverine Hotel, Detroit . . G. S. Maxlow, Ford Motor Co., *"Preventative Maintenance In The Foundry."*

Eastern Canada . . April 14 . . Sheraton-Mount Royal Hotel, Montreal . . *Invite Your Boss Night*, H. J. Weber, AFS, *"How AFS Can Help Management In Safety, Hygiene & Air Pollution Control."*

Metropolitan . . May 8 . . Military Park Hotel, Newark, N. J. . . C. E. Wenninger, Beardsley & Piper Div., Pettibone Mulliken Corp., *"Quality Castings Through Better Molding Sand Practice."*

Mid South . . April 14 . . Claridge Hotel, Memphis, Tenn. . . W. Ellison, Archer-Daniels-Midland Co., *"Causes and Cure of Casting Scrap Due to Cores."*

Mo-Kan . . April 20 . . Fairfax Airport, Kansas City, Kan. . . R. L. Johnston, Whirl-Air-Flow Corp., *"Pneumatic Conveying and Boring Injection."*

Northeastern Ohio . . April 13 . . Manger Hotel, Cleveland . . Prof. J. M. Juran, *"Motivation for Quality."*

Northern California . . April 17 . . Spenger's Fish Grotto, Berkeley, Cal. . . Prof. W. M. Miller, University of Washington, *"Hydraulics of Gating Systems."*

Northern Illinois & Southern Wisconsin . . April 11 . . Elks Club, Rockford, Ill. . . J. S. Schumacher, Hill & Griffith Co., *"Molding Methods vs. Sand Testing."*

Northwestern Pennsylvania . . April 24 . . Erie, Pa. . . Les Giblin, *"Human Relations."*

Ontario . . April 21 . . Seaway Hotel, Toronto, Ont. . . *"Ladies' Night."*

Philadelphia . . April 14 . . R. Carpenter, Hanna Furnace Corp., *"The Cupola: Coke Burner or Iron Melter."*

Piedmont . . May 5 . . Admiralty Hotel, Norfolk, Va. . . H. W. Schwengel, Modern Equipment Co., *"New Developments in Equipment for Melting and Charging."*

Pittsburgh . . April 17 . . Hotel Webster Hall, Pittsburgh, Pa. . . J. Stana, Warner-wasey Co., *"Foreman Training."*

Quad City . . April 17 . . LeClaire Hotel, Moline, Ill. . . C. E. Drury, Central Foundry Div., GMC, *"Pouring Effect on Scrap."*

Rochester . . May 2 . . Manger Hotel, Rochester, N. Y. . . *Election of Officers.*

Saginaw Valley . . May 4 . . R. Podelsak, Chevrolet Div., GMC, *"Customers Viewpoint of Castings."*

Southern California . . April 14 . . Rodger Young Auditorium, Los Angeles . . Prof. W. M. Miller, University of Washington, *"Hydraulics of Gating Systems."*

Tennessee . . April 28 . . Read House, Chattanooga, Tenn. . . *Annual Ladies' Night.*

Texas . . April 28 . . Angelina Hotel, Lufkin, Texas, *"Symposium on Casting Defects."* Panel Moderator: H. H. Judson, University of Houston.

Texas . . San Antonio Section . . April 18 . . Kincaid-Osburn Steel Castings, Inc., San Antonio, Texas . . Bill Merkel, *"Close Tolerance Castings."*

Toledo . . May 3 . . Plant Trip . . Central Foundry Division GMC, Defiance, Ohio.

Twin City . . April 11 . . Jax Cafe . . Minneapolis . . R. T. Lewis, Keen Foundry Co., *"Are Your Costs Reliable?"* . . **May 2 . . Helm Kausel Foundry, Minneapolis** . . F. F. Junger, *"The Good and Not so Good In Casting Supply Relations."*

Washington . . April 20 . . Engineers Club, Seattle, Wash. . . Prof. W. M. Miller, University of Washington, *"Hydraulics of Gating Systems."*

Western New York . . May 4 . . Sheraton Hotel, Buffalo, N. Y.

Wisconsin . . April 14 . . Hotel Schroeder, Milwaukee . . *Sectional Meeting* . . **May 5** . . *Old Timers-Apprentice Night.*

Foundry Trade News

Foundry Educational Foundation . . . has named four 1961 Wheelabrator Fellowship winners. They are: *Robert G. Chambers,* 24, Jonesboro, Ga., who has just completed two years of active duty in the U. S. Army after establishing an exceptional record at Georgia State College. He plans to do graduate work at the University of Alabama. *David B. Routledge,* 22, Lexington, Ky., held an F.E.F. scholarship in his undergraduate days at the University of Kentucky and will continue his studies there.

William F. Stuhrke, 21, Cleveland, who will graduate in June from Case Institute of Technology with a degree in metallurgical engineering and will continue his study at Case at the graduate level. *Thomas H. Steffen,* 22, Chicago, who will graduate from University of Illinois in June with a degree in Mechanical Engineering. In addition to being a Tau Beta Pi he was awarded the scholarship key for class honors three times. He will study engineering and marketing at the graduate level.

The 14th annual college-industry conference will be held April 19-20 at the Hotel Statler-Hilton in Cleveland. The program is built around two major themes, the F.E.F. graduate and the F.E.F. undergraduate. Former F.EF. scholarship holders will discuss the F.E.F. graduate, his role in design and application, technical sales and service, supervision and management, and education. Under the undergraduate and the foundry industry will be discussed summer employment and case histories.

Gene Conreaux & Co. . . . Indianapolis, has been named as distributors for Lawrence Refractories in Indiana, eastern Illinois and northern Kentucky.

Aluminum Association . . . recently sponsored a 75th anniversary program at Oberlin College, Oberlin, Ohio, the town in which Martin Hall discovered the electrolytic reduction process.

Dow Chemical Co. . . . Midland, Mich., has formed a new Metals Dept. to be responsible for various Dow activities in magnesium and other primary metals including development of primary magnesium for die casting, chemical uses of magnesium, and other metals. The new department will be separate and distinct from Dow Metal Products Co. Div., which remains responsible for processing and fabrication of aluminum, magnesium, and other mill products. With the establishment of the new Metals Dept. Dow's Magnesium Sales will now be known as Metals Sales handling the sale of primary magnesium, alloy ingot, and cast anodes, as well as other metals.

American Zinc Institute . . . has moved its Detroit headquarters to 638 New Center Bldg., Detroit, 2.

Kaiser Refractories & Chemicals Div. . . . Kaiser Aluminum & Chemical Corp., has changed the name of two of its sales subsidiaries to that of the parent. These are: Fire Brick Service Co., Indianapolis, Frank B. Boyd, Jr., district sales manager; and Fire Brick Specialties Co., Rock Island, Ill., Frank M. Moser, district sales manager.

Detroit Electric Furnace Div. . . . Kuhlman Electric Co., has moved from Bay City to 11405 E. State Fair Ave., Detroit, 34.

Ford Foundation . . . has given $3,110,000 to four Southern universities to strengthen and expand engineering at the doctoral level. Receiving grants are: Georgia Institute of Technology, $680,000; University of Florida, $695,000; North Carolina State College, $760,000; and University of Texas, $975,000.

Allis-Chalmers Mfg. Co. . . . is liquidating its No. 2 Gray Iron Foundry building, Milwaukee, to make room for a tractor assembly line.

Casting Engineers . . . is the new name for Jelrus Precision Casting Co., New York, assuming the same corporate identity as its parent company in Chicago. Casting Engineers is a division of Consolidated Foundries & Mfg. Corp.

Radionics, Inc. . . . now has its entire line of gamma radiographic cameras, sources, and equipment sold exclusively in U. S. and Canada by Philips Electronics Div., Philips Electronic & Pharmaceutical Industries Corp. Radionics will continue to independently market a new line of nuclear gages.

Society of Die Casting Engineers . . . has elected officers: President, John L. MacLaren, Aluminium Ltd. Sales,

Inc., New York; Vice-President, Earle W. Rearwin, Reed-Prentice Div., Package Machinery Co., East Longmeadow, Mass.; Secretary, M. R. Tenebaum, Lester-Phoenix, Inc., Cleveland; Treasurer, Lee G. Axford, Ford Motor Co., Detroit.

Hamilton Foundry, Inc. Foundation . . . and Decatur Casting Co. Foundation, have given stock valued at $103,105 to the University of Cincinnati to establish in perpetuity a chair honoring Peter E. Rentschler, president, Hamilton Foundry, Inc., Hamilton, Ohio.

Kramer Brothers Foundry Co. . . . Dayton, Ohio, has purchased controlling stock interest in Dayton Automatic Stoker Co., Dayton. In 1959 Kramer Brothers purchased the stoker business of Brownell Boiler Co. Since then Brownell Stoker & Combustion Co. has been operating as a separate corporation. Kramer Brothers will furnish all gray iron castings used by Dayton Automatic Stoker.

Casting Equipment, Inc. . . . has been formed by Allen J. Filipic and J. Doyle Robbins, formerly sales engineers for Osborn Mfg. Co., Cleveland, and will represent foundry equipment manufacturers in Ohio, western Pennsylvania, West Virginia, and eastern Kentucky.

Eastern Co. . . . is the new name of Eastern Malleable Iron Co., Naugatuck, Conn. The company, which is undergoing a diversification program, operates eight divisions.

Lord Chemical & Equipment Div. . . . Wheelabrator Corp., is the new corporate name for the former Lord Chemical Corp., York, Pa. It will continue to manufacture in York and Red Lion, Pa. The Lorco name will apply to all products in this division.

General Electric Co. . . . Waterford, N. Y. named Frederic B. Stevens, Inc., Detroit, as a distributor of its silicone products for the foundry industry. Stevens organization, will handle distribution of silicone products for foundry use in the northeastern and midwestern sections of the country. Stevens will also handle line of G-E solvent-type parting agents as well as high temperature silicone greases and fluids.

Metcut Research Associates, Inc. . . . Cincinnati, announces formation of a machining data center, to aid solving aerospace maching problems. Difficult-to-machine materials such as tungsten and ultra high strength steels and new, novel processes for removing metal will be studied. The data center, Cincinnati, will serve as a national center for collection, analysis, correlation, dissemination, and interpretation of machining information, and to assist science and industry through better knowledge.

Newton-New Haven Co. . . . New Haven, Conn., appointed the Hilker Co. as exclusive sales representatives in the southeastern territory, for custom producers of zinc and aluminum die castings.

Cleveland Metal Abrasive . . . Cleveland, has completed its Cleveland plant expansion program, and introduced new specialized services to steel mills, foundries, enameling plants, and forge shops.

Harcast Co., Inc. . . . has acquired Precision-Cast Products of Philadelphia, Penn.

Precision Metalsmiths, Inc. . . . has acquired Intricast, Inc. Intricast will operate as Precision Metalsmiths, Inc., Intricast Div., Loudonville, Ohio.

For The Asking

Build an idea file for improvement and profit. Circle numbers on literature request card, page 129, for manufacturers' publications.

Induction heating and melting . . . bulletin subjects include: low and high frequency melting; frequency convertors and accessories; vacuum melting and degassing; induction billet heaters for aluminum, copper, steel, titanium, and other metals; charts on selection of proper frequency and melting rates in pounds per hour. Ajax Magnethermic Corp.

Circle No. 49, Pages 129-130

Special foundry belting . . . eight different types of belting designed for foundry service are described in brochure. Covering a complete range of conveying and elevating operations, it details specific belting recommendations for nearly every usage and operating condition encountered in a foundry—from casting conveying to hot shakeout elevating at temperatures 600 F. Imperial Belting Co.

Circle No. 50, Pages 129-130

Refractory insulation materials . . . described in folder. Products provide high thermal efficiency and mechanical strength from room temperatures to 1900 F. Recommended thicknesses for insulation for various temperatures are outlined. Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Corp.

Circle No. 51, Pages 129-130

Wet abrasive cutting unit . . . designed for cutting-off operations in steel mills, forge shops, and other heavy industries is described in bulletin. Using a 34 in. diameter cutting wheel, the unit cuts solids, tubing, and structurals at a rate of 7 to 10 square inches per minute. Allison Campbell Div., American Chain & Cable Co.

Circle No. 52, Pages 129-130

Metal cleaning . . . and finishing equipment provided by the company, in addition to the firm's export facilities, are described in brochure. Overseas installations of blast cleaning equipment and dust and fume control equipment are pictured. Wheelabrator Corp.

Circle No. 53, Pages 129-130

Magnesite-chrome bricks . . . literature describes availability of burned, magnesite-chrome basic brick, with a dimpled metal jacket that provides built-in expansion. Properties, applications, advantages, chemical analysis, installation data and other information is presented. H. K. Porter Co.

Circle No. 54, Pages 129-130

Hoists and cranes . . . are illustrated in manual. Highlighted are end trucks, enclosed conductors, hoists, crane drives and fluid drive motors, trolleys, runway rails, hangar fittings, and other components for building top riding and underslung cranes from 1 to 15 ton capacity. Consolidated Crane & Engineering Corp.

Circle No. 55, Pages 129-130

Coupling line . . . including torsionally resilient models and additional coupling types is contained in a 24-page catalog. Includes selection data, engineering data, dimensions, typical applications, and special models. Falk Corp.

Circle No. 56, Pages 129-130

Vacuum furnace . . . brochure, 24 pages, covering principles, vacuum arc melting types, inducted heated furnaces, and resistance heated furnaces. Includes diagrams, technical data, and applications. Consolidated Vacuum Corp.

Circle No. 57, Pages 129-130

Potentiometer . . . available as strip chart recorder, circular chart recorder, and circular scale indicator, easily converted to any model. Twenty-four page brochure explains operating features. Minneapolis-Honeywell Regulator Co.

Circle No. 58, Pages 129-130

Needed inventions . . . in metallurgy and foundry fields for use by the Armed Forces and other government agencies are outlined in booklet. Examples of developments wanted are: fabrication techniques for rocket motor combustion chambers; high temperature, high stress materials in temperature range of 1500 to 2000 F.; fabrication techniques for refractory metals. National Inventors Council.

Circle No. 59, Pages 129-130

Panel-type filters . . . a recently developed panel-type air filter is illustrated in bulletin. Material used in the filter is described as a strong fiber with a highly irregular cross-section that stops and holds unusually large quantities of dust. A diagram indicates typical arrangements for the standard system. Union Carbide Development Co., Div. Union Carbide Corp.

Circle No. 60, Pages 129-130

Special motors . . . literature stresses stator insulations and full-protection features of motors which operate under severe conditions. Depicted are a series of tests given the units, including abrasion, corrosion, thermal, and clogging. Performance charts and various applications are also given. Allis-Chalmers Mfg., Co.

Circle No. 61, Pages 129-130

Strengths of nuts, bolts . . . a basic explanation of the different kinds of strengths involved in metal bolts and nuts, plus how these strengths are achieved, is available in illustrated booklet. Terms such as shear strength, tensile strength, yield strength, elongation, cold working, stress corrosion, creep strength, thread strength, temperature control, and metal fatigue are explained. H. M. Harper Co.

Circle No. 62, Pages 129-130

Proper use of fluxes . . . subject of booklet is how proper use of scientifically compounded fluxes aid foundries and die casters in production of superior aluminum castings and help reduce rejects. Includes detailed instructions on using each of five types of fluxes. Apex Smelting Co.

Circle No. 63, Pages 129-130

Safety posters . . . the 1961 directory of occupational safety posters illustrates 780 different poster designs on all phases of safety. Wide selection, touching on all phases of accident prevention, includes cartoon and humorous, photographic, serious, subtle and straight-to-the-point posters. National Safety Council.

Circle No. 64, Pages 129-130

Electrical industrial trucks . . . literature illustrates how manufacturing techniques affect the value and performance of units. Also presented are standard trucks adapted to solve spe-

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5	17	29	41	53	65	77	89	101	113
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126	138	150	162	174	186	198	210
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130	142	154	166	178	190	202	214
131	143	155	167	179	191	203	215
132	144	156	168	180	192	204	216

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cial materials handling problems in steel mills, foundries and other fields. Elwell-Parker Electric Co.

Circle No. 65, Pages 129-130

Shell core operation . . . at Albion Malleable Iron Co., Albion Mich., is described in brochure, which illustrates the use of resin-sand cores in commercial production. Shalco Div., National Acme Co.

Circle No. 66, Pages 129-130

Solving gas porosity . . . in aluminum castings with degassing material is discussed in 4-page bulletin. Designed to produce pressure-tight castings of maximum density, it is a metallurgical compound plunged to the bottom of aluminum melt. It evolves insoluble chlorine and other volatile chlorides which bubble through molten metal as scavenging gases, removing hydrogen and non-metallic inclusions which cause defects and porosity in the casting. Foundry Services, Inc.

Circle No. 67, Pages 129-130

Hose fittings . . . catalog lists hose fittings and assemblies that are detachable, reusable, and designed for medium and high pressure industrial uses. Featured are specification tables of single wire braid hose and fittings; single wire braid medium pressure hose assemblies; double wire braid hose and fittings; and double wire braid high pressure hose assemblies. Lenz Co.

Circle No. 68, Pages 129-130

High vacuum components . . . including mechanical and diffusion pumps, valves, gages, accessories, portable pumping systems, coaters, furnaces, electron beam welders, altitude chambers, and freeze drying equipment are featured in catalog. NRC Equipment Corp.

Circle No. 69, Pages 129-130

Roller hearth furnaces . . . gas or electric, are described in bulletin. Units offer high production, top quality, economical annealing, hardening, brazing, sintering, and general heat treating. Drawings and copy explain design features of various components of the furnaces. General Electric Co.

Circle No. 70, Pages 129-130

Blast cleaning . . . five heavy-duty blast cleaning barrels, with work capacities ranging from 15 to 102 cubic feet, are described in 16-page bulletin, illustrated with cut-away drawings, photos, and sketches. Specifications and over-all dimensions are also outlined. Case histories depict how units have reduced costs at different installations. Pangborn Corp.

Circle No. 71, Pages 129-130

Steel casting specs . . . revised edition of a Summary of Steel Castings Specifications is announced. Prepared by the Specifications Committee of S.F.S.A. it includes a major change in Federal Specification QQ-S-681. Several new classes have been added to specification A-296 and the property values have been changed on some classes in specifications A-297 and A-351. Two new methods of testing applicable to steel castings have been adopted also. Individual copies are free of charge from members. Steel Founders' Society of America.

Circle No. 72, Pages 129-130

Atmospheric burners . . . gas-fired, with maximum firing capacities from 10,000 to 2,750,000 Btu/hr are depicted in bulletin. Provided are dimensions, specifications, engineering data, and ordering information for pipe, wheel, immersion, ring, box and "U"-type burners, atmospheric injectors, and packaged burners. Eclipse Fuel Engineering Co.

Circle No. 73, Pages 129-130

Thermocouples . . . pressure probes and allied components are featured in 60-page catalog, which contains complete specifications, details, and prices. Advanced Dynamics, Inc.

Circle No. 74, Pages 129-130

Wet water . . . systems for industry are described in 4-page bulletin. Applications of systems to sand conditioning, core mixing, core and mold washes, cupola lining, and other foundry uses are shown. Various advantages in terms of increased production and lower costs are offered. Aquadyne Corp.

Circle No. 75 ,Pages 129-130

Foamed solvent . . . four-page pamphlet explores new technique of cleaning industrial equipment, utilizing lightweight foamed solvent for greater efficiency, economy. Dow Industrial Service.

Circle No. 76, Pages 129-130

Die release agents . . . are described in two data sheets. One material is utilized for large, intricate castings. The other is for aluminum die and permanent mold casting. E. F. Houghton & Co.

Circle No. 77, Pages 129-130

Gas purification catalysts . . . to produce industrially pure gases are described in bulletin. Removal of impurities to less than 1 part per million can be achieved with the all-metal catalysts. They operate at high or low pressure, and at temperatures up to 1500 degrees F. Catalytic Combustion Corp.

Circle No. 78, Pages 129-130

Ceramic cutting tools . . . new catalog, a 28-page, 3-hole punched folder, gives the properties data and specs and prices on throwaway inserts, heavy duty button inserts, solid inserts, unground blanks, single point tools and tool holders. Carborundum Co.

Circle No. 79, Pages 129-130

Safety Binders . . . . with modern castings

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New Products and Processes

What's new in foundry methods and equipment? Summaries of many are presented below. Circle corresponding number on free postcard, page 129. Mail it to us; we'll do the rest.

Parting Material Reduces Molding Time

Water soluble parting material reduces molding time and produces better casting finish. Films produced in sprayed parting application provide combined advantages of fast drying, good adhesion to irregular and sharp contours, and surface tension that covers minor mold defects. Film can be removed simply by stripping or warm water wash. Two types of parting material are supplied; one, bright fluorescent color to help control of parting film thickness; another which is colorless to eliminate need of film removal. Schwartz Chemical Co.

Circle No. 1, Pages 129-130

Dust Collector Gives High Filtration Efficiency

Unit consists of cylindrical felt filters in which filter action takes place as gas passes from inside of filter tube to outside. As filter cake becomes thick with accumulated dust, pressure switch actuates circular blow rings carrying air jets which blow slowly up and down the entire length of the filter tubes removing the dust in small increments. Even on submicron particles, extremely high efficiencies are obtained, generally as high as 99.99%. Western Precipitation Div., Joy Mfg. Co.

Circle No. 2, Pages 129-130

Automatic Mold Casting Machine Features Two-Up Pouring

A permanent mold casting machine pours "two-up" with one man, eliminates turbulence, pours consistently at a given setting, adjusts for any rate of pour, prevents flash at bottom of mold and assures progressive solidification. Dual power unit automatically moves to vertical position and pours metal evenly down gentle incline and, after pre-set cooling interval, automatically opens and ejects casting. Stahl Specialty Co.

Circle No. 3, Pages 129-130

25000 Pound Zinc Pigs Make Handling Easier

Large tonnage consumers of slab zinc may find considerable savings if they are in a position to use 2500 pound pigs. These units measure 36" x 28" x 16" and are designed with legs and wings under which lift-truck prongs may be placed in either direction for ready transportation. Tapered holes in the top of the pig may be used for moving the unit with crane-hoist tongs. New Jersey Zinc Co.

Circle No. 4, Pages 129-130

Horizontal Centrifugal Casting Unit Produces Quality Liners

Horizontal centrifugal casting machine is almost completely automatic. Produces centrifugally cast iron cylinder liners in high production, can make all sizes of liners for use in engines, with a minimum of labor and a consistently low scrap rate. Centrifugal Casting Machine Co.

Circle No. 5, Pages 129-130

Continuous Clay Washer Speeds Determinations

Continuous clay washer, based on the elutriation principle, is offered as a low-cost, simple apparatus for the determination of A.F.S. clay. The sand is scrubbed continuously by a high velocity jet of water from the motor-driven agitator tube and the

clay is carried out of the vessel by the water flow as it rises to the outlet tube at the top. This continuous washing reduces the total test time by as much as one-half for some sands and eliminates the repeated syphonings required with the manual method thus saving considerable operator time. Harry W. Dietert Co.
Circle No. 6, Pages 129-130

High Purity Zinc Alloy And Hardener Alloys

High purity zinc die casting alloy and a special aluminum hardener have been announced. Both products require meticulous care in preparation, manufacturer cautions, to enable die casters to obtain claimed advantages over traditional alloys. Quantometer analyses have been found particularly beneficial in maintaining the necessary magnesium and nickel content in low, but controlled, quantities. Apex Smelting Co.
Circle No. 7, Pages 129-130

Variable Speed Turntable Aids Steel Casting In Cut-off Work

The cutting-off operation in processing of large steel castings has reportedly been vastly improved through the use of a variable-speed turntable. With the new system, the gas cutting torch is clamped in a stationary position and the casting revolves past it. The operator mounts the casting on a four-foot turntable then lights the torch and revolves the casting past the torch at the necessary cutting speed. This close cutting speed control enables the operator to obtain much more consistency, smoother cut, leaving just the right amount of material for finishing. Upon completion, operator can rapidly revolve the turntable manually to any other position so that another raise can be cut off. Macton Machinery Co.
Circle No. 8, Pages 129-130

Zinc Alloy Offers Advantages Over Earlier Types

Evolutionary zinc die casting alloy has the same desirable mechanical characteristics as other alloys but casting properties that permit faster production rates, fewer rejects and better surface finish. New alloy makes possible larger, more complex castings with thinner wall sections, and reduces time. New Jersey Zinc Co.
Circle No. 9, Pages 129-130

New Books for You . . .

1960 Supplement to the Metal Cleaning Bibliographical Abstracts. 36 pages. Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. This supplement covers the period 1958 through early 1960. There are 114 references as well as 100 newly added references prior to 1958. New metals present new cleaning problems which must be solved by advanced techniques or combinations of older methods. Ultrasonic cleaning, in-place cleaning of equipment in plants, or of pipe lines, and the cleaning of electronic components are receiving much consideration for the special problems involved. The reader will find not only references of practical application, but also on theory and lab evaluation.

Noise Reduction . . . Leo L. Beranek. 752 pages. McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36. An authoritative guidance on the theory and practice of noise reduction. The book explains fundamentals underlying noise and vibration control, and takes a tour through design and engineering of buildings, installations, industrial machinery, home appliances, transportation facilities and other projects. It covers material applicable over a wide range of fields, for understanding acoustical problems in everyday situations and shows what techniques have been successfully used to solve typical problems. Included is information on: behavior of sound waves; use of decibel scale to describe great ranges of sound power; selection of instrumentation for noise surveys; limitations and applications of various types of instruments; sound propagation in large and small enclosures; and basic properties of acoustical materials.

Nuclear Fuel Element Development . . . R. Carson Dalzell. 14 pages. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. 1960. This is a lecture available in printed form, which was delivered before the 63rd annual meeting of A.S.T.M. the 9th H. W. Gillett Memorial Lecture. Dr. Dalzell reviews the tremendous strides made in the field as well as pointing out the many problems that still exist. While the achievements have been many in the reactor field (approximately 140 reactors are operating in the United States) the problems of fuel element design are far from solved.

Epoxy Resins, Their Applications and Technology . . . Henry Lee and Kris Neville. 305 pages. McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, 1957. A comprehensive guide to field of epoxy resins. It covers the chemistry of their preparation and application in industry. Information is given on their synthesis and curing mechanisms, curing agents, and the various materials used as fillers and modifiers. Emphasis is on the engineering versatility, range and potentialities of the epoxies. Industrial applications in laminates, adhesives, coatings, castings, foams, etc. are discussed. Also covered are application techniques handling characteristics, and methods for characterizing cured and uncured resins.

Let's Get Personal . . .

Robert C. Stokes . . . is now eastern sales manager, Specialloy, Inc., Chicago, and will headquarter in Philadelphia. He is chairman of the AFS Philadelphia Chapter.

Carter DeLaittre . . . is vice-president and works manager, Minneapolis Electric Steel Castings Co., Minneapolis. **A. Donald Moll** is now vice-president and sales manager. Other officers re-elected are: President, **Robert C. Wood**; Vice-President, **William E. Niemackl**; and Secretary-Treasurer, **Orvel A. Bakke.**

G. Blair Sheers . . . is chairman of the board, Standard Horse Nail Corp., New Brighton, Pa., replacing the late **Fred I. Merrick.** Other officers: **R. S. Merrick**, vice-president; **J. D. Brubaker**, treasurer; **C. K. Kennedy**, secretary and assistant treasurer.

Albert E. Salatka . . . general manager, Marion Malleable Iron Works, Marion, Inc., has been named vice-president, Malleable Iron Works Div., Chicago Railway Equipment Co.

W. R. Bean . . . retired, AFS President from 1920 to 1922, has been cited for meritorious service and outstanding contributions by Virginia Polytechnic Institute, Blacksburg, Va.

Roger J. Metzler . . . is assistant to the general manager, Metals & Refractories Div., Howe Sound Co., Philadelphia. The division is composed of Howe Refining Co., Frank Samuel & Co., and WaiMet Alloys Co.

William C. Hughes . . . is safety supervisor for Portland, Ore., operations of ESCO Corp., succeeding **Arthur W. Nelson,** who retired.

Steve Stasko . . . is chief metallurgist, Mackintosh-Hemphill Div., E. W. Bliss, succeeding **Edward P. Sandbach** recently promoted to manager, manufacturing operations.

Henry A. Bednarski . . . is now sales engineer, Furnace Products Div., Basic, Inc., Cleveland. He will be located in Philadelphia.

Edward J. Klein . . . and **Jack Weir** head the new St. Louis office in St. Louis of Scientific & Process Instruments Div., Beckman Instruments, Inc. Klein will handle scientific instruments, Weir, process instruments.

Thomas F. Gallagher . . . is general sales manager, Davis Fire Brick Co., Oak Hill, Ohio. He will act in this capacity for companies associated with Davis–Sivad Ceramic Corp., Ohio Fire Brick Co., and Cambria Clay Products Co.

Edward N. Harris . . . elected vice-president of sales, Bohn Aluminum & Brass Corp., Detroit.

Egon von Mauchenheim . . . is now vice-president, Lester B. Knight & Associates, and concurrently becomes manager of its German affiliate, Lester B. Knight & Associates, G.m.b. H., Dusseldorf.

W. J. Rave . . . is manager of the new Metals Dept., Dow Chemical Co., Midland, Mich. **Hilary A. Humble** is sales manager. The new depart-

ment is responsible for various Dow activities in magnesium and other primary metals but is separate and distinct from Dow Metal Products Co. Div.

William S. Pellini . . . head, Metallurgy Dept., Naval Research Laboratories, Washington, D. C., and who will receive the AFS John A. Penton Gold Medal at the 1961 Castings Congress, has been awarded the Navy Distinguished Service Award, the highest award the Navy can give a civilian.

Earl A. Garber . . . named chairman of the board of Harbison-Walker Refractories Co. **A. Brent Wilson** has been elected president, to fill the vacancy created by Garber's elevation.

Laurence F. Granger . . . named advertising manager for National Carbon Co., Div. Union Carbide Corp.

Thomas J. Ready, Jr. . . . executive vice president of Kaiser Aluminum & Chemical Corp., elected a member of the Corporation's board of directors.

Roy A. Frost . . . assigned to engineering sales as service engineer at the Vanadium Corp. of America offices in Chicago. Also announced was the appointment of **Robert F. Jones** as district representative with Vanadium's district office in Cleveland.

Robert L. Snook . . . named as manager, Industrial Dept., Magnet Cove Barium Corp., succeeding **George H. Moore**, recently named as vice-president, marketing. Snook remains at the Houston, Texas, office.

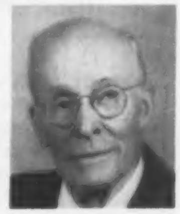
Roger S. Van Der Kar . . . is now general sales manager of Hanna Furnace Corp., Detroit. He is Chairman of the AFS Detroit Chapter. **A. W. Gallup** promoted to Detroit district sales manager and **Sherman B. Burke** appointed to the office of vice president, sales.

Donald L. Moore . . . is sales manager, Baroid Chemicals, Inc., Houston, Texas. **Howard G. Monroe**, assistant sales manager, has direct supervision of sales to the foundry industry.

Leslie F. Schurck . . . named general works manager, Cooper Alloy Corp., Hillside, N. J.

obituaries

Thomas S. Hodge, 82, W. S. Hodge Foundry, Inc., Greenville, Pa. At the age of 14, he started in the foundry of Hodge Mfg. Co., established by his father in 1876, and dissolved in 1937. He then started W. S. Hodge Foundry, Inc., with a son, Wesley S. Hodge and later joined by a younger son, Thomas W. Hodge.



T. S. Hodge

J. A. Shanafelt, 88, identified with the foundry industry since 1893 and board chairman of Shanafelt Mfg. Co., Canton, Ohio.

Andrew F. Howe, 85, inventor, who in 1944 received a $1,164,201 settlement of a patent claim for mold forms he devised for making castings for railroad cars and locomotives.

Classified Advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 35c per word, 30 words minimum, prepaid. **Positions Wanted** . . 10c per word, 30 words minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 words. **Display Classified** . . Based on per-column width, per inch . . 1-time, $22.00 6-time, $20.00 per insertion; 12-time, $18.00 per insertion; prepaid.

HELP WANTED

PLANT ENGINEERS
Experienced on layout of all types of foundry equipment, material handling and material flows. Send complete details on work history, education and family status. Include recent photograph. All replies confidential. **Box F-140, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY MANAGER
Must have successful experience in the production of malleable, pearlitic and nodular iron castings. Metallurgical or engineering background required; FEF training desirable. Preferred age 35-45. In return for these requirements we offer an outstanding opportunity with one of the major producers in the country. Location is in the Mid-West. Excellent starting salary and benefits. Send complete details – education, work history, family status, plus a recent photograph. All information will be held in strict confidence. **Box D-106 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY ENGINEER
$8,000 to $10,000
Young Engineer, interested in assured future with a rapidly expanding, progressive foundry where competence is rewarded with advancement. Client pays all expenses. Contact Paul Sheldon
MONARCH PERSONNEL
28 East Jackson Blvd. Chicago 4, Illinois

FOUNDRYMEN
when you need SUPERVISORY or TECHNICAL men why not consult a man with actual foundry experience plus 15 years in finding and placing FOUNDRY PERSONNEL.
Or if you are a FOUNDRYMAN looking for a new position you will want the advantages of this experience and close contact with employers throughout the country.
For action contact: John Cope
DRAKE PERSONNEL, INC.
29 E. Madison St., Chicago 2, Illinois
Financial 6-8700

PLANT ENGINEER
To direct all plant engineering functions in large malleable foundry located in the Mid-West. Degree required. Age preference 30-40. Send complete details in confidence. **Box D-104 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY SUPERINTENDENT
With minimum of ten years supervisory experience. Must have strong malleable background. Engineering degree preferred. Age 35-40. All replies will be held in strictest confidence, and should include complete work history, education and personal data. **Box D-105 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

RESEARCH METALLURGIST: To work on alloy cast iron, recent M.S. degree or B.S. with 3 years appropriate experience. Location, Toronto, Canada. Send complete resume to **Box No. D-103 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

POSITION WANTED

METALLURGIST: carbon, alloy and stainless steels; molding, melting and processing; Supervisory and Engineering experience (17 years) seeks broader, challenging position. Reply **Box D 100 P. MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRYMAN, well experienced in gray iron and steel foundry operations, light and heavy castings, synthetic, natural and cement-bonded sands, strong in modern foundry practice and quality control. Age 39, single, technical college graduate. Write. **Box D-101 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

ENGINEER, age 37, with fourteen years experience in the field of foundry operation and engineering, desires a responsible position of foundry engineer, plant engineer or foundry equipment designer. **Box D-107 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SALES REPRESENTATIVE: Ambitious, neat appearing, young salesman presently representing heavy jobbing foundry would like additional line for Michigan territory. Write **Box D-102 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOR SALE

ONE USED #3 UNIT DRIVE SIMPSON MULLER. Good condition. **Box B-107 S, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Detroit Rocking Indirect Arc Electric Furnace Type LFC, 125 KW, Capacity 350 lbs. cold scrap, 500 lbs. of molten metal. Two shells, complete with automatic electrode control, main control panel and power transformers for 12,000 volt primary power supply. All equipment used very little and in excellent condition. Immediately available. Make offer to: **Box B-111 S, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

REVERBERATORY ALUMINUM FURNACE 3,000 lb. capacity. Complete with overhead hood. Has been used a short time. Can be inspected at our plant. Will sell very cheap. Casting Masters, Inc., 2640 W. Wilcox, Chicago 12, Ill.

QUALITY EQUIPMENT
SAVE AT LEAST 50%
B & P #70 Speedmuller
B & P Motive Speedslinger
10' Top Charge Mltg. Furnace
TOCCO 50 KW—200 KW Ind. Heaters
48" x 42" WHEELABRATOR Tumb.
Your largest dealer for all foundry equip't.
UNIVERSAL Mach'y & Equip't Co.
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ENGINEERING SERVICES

FOUNDRY CONSULTANT — NON-FERROUS Sand casting — permanent mold casting — centrifugal casting — in aluminum — brasses — bronzes — 30% leaded bronze — aircraft quality bearings and castings — **ED JENKINS, West Palm Beach, Florida — PHONE: Temple 2-8685.**

Future Meetings and Exhibits

April 10-12 . . American Institute of Mining, Metallurgical & Petroleum Engineers, Open Hearth Steel Conference. Sheraton Hotel, Philadelphia.

April 12-14 . . American Institute of Mining, Metallurgical and Petroleum Engineers, International Symposium of Agglomeration, Sheraton Hotel, Philadelphia, Pa.

April 19-20 . . Foundry Educational Foundation, Annual College-Industry Conference. Statler-Hilton Hotel, Cleveland.

April 18-20 . . American Welding Society, Annual Meeting and Welding Show. Commodore Hotel and Coliseum, New York.

May 8-12 . . AFS 65th Castings Congress, Civic Auditorium, San Francisco.

May 9-11 . . Material Handling Institute, Eastern States Show. Convention Hall, Philadelphia.

May 10-12 . . National Industrial Sand Association, Annual Meeting. The Homestead, Hot Springs, Va.

May 17-19 . . Society For Nondestructive Testing, Eastern Regional Convention, Sheraton-Mt. Royal Hotel, Montreal, Que. Canada.

May 22-25 . . American Society of Mechanical Engineers, Conference and Design Engineering Show, Cobo Hall, Detroit.

May 22-26 . . American Society of Tool and Manufacturing Engineers. Engineering Conference and Exhibit, New York.

June 8-9 . . Malleable Founders Society, Annual Meeting. The Broadmoor, Colorado Springs, Colo.

June 11-15 . . 54th Annual Air Pollution Control Association Meeting, Hotel Commodore, New York City.

June 15-16 . . AFS Chapter Officers Conference. LaSalle Hotel, Chicago.

June 18-20 . . Alloy Casting Institute, Annual Meeting, Hot Springs, Va.

June 18-24 . . 28th International Foundry Congress, Vienna Imperial Castle, Vienna, Austria.

June 20-21 . . Investment Casting Institute Technical Course, Case Institute of Technology, Cleveland, Ohio.

June 22-24 . . AFS Penn State Regional Foundry Conference. Penn State University, University Park, Pa.

June 25-30 . . American Society for Testing Materials, Annual Meeting. Chalfonte Haddon Hall, Atlantic City, N. J.

Aug. 28-Sept. 1 . . American Society of Mechanical Engineers, International Heat Transfer Conference, University of Colorado Campus, Boulder, Colorado.

Sept. 3-8 . . American Chemical Society, Fall Meeting. Chicago.

Sept. 20-23 . . American Ceramic Society, Enamel Division, French Lick-Sheraton Hotel, French Lick, Ind.

Sept. 21-22 . . Missouri Valley Regional Conference, Rolla School of Mines, Rolla, Missouri.

Sept. 24-26 . . Steel Founders' Society of America, Fall Meeting. The Homestead, Hot Springs, Va.

Oct. 13-14 . . Northeastern Foundry Conference, Massachusetts Institute of Technology, Cambridge, Mass.

Oct. 16-21 . . National Industrial Sand Association, Semi-Annual Meeting. The Greenbrier, White Sulphur Springs, W. Va.

Oct. 18-20 . . Gray Iron Founders' Society, Annual Meeting. Royal York Hotel, Toronto, Ont.

Oct. 19-21 . . Foundry Equipment Manufacturers Assn., Annual Meeting. The Greenbrier, White Sulphur Springs, W. Va.

Oct. 23-27 . . American Society for Metals, Detroit Metal Show (43rd National Metal Congress and Exposition), Cobo Hall, Detroit, Mich.

Nov. 13-15 . . Steel Founders' Society of America, Technical & Operating Conference. Pick Carter Hotel, Cleveland.

Nov. 15-17 . . National Foundry Association, Annual Meeting. Savoy-Hilton Hotel, New York.

Dec. 6-8 . . American Institute of Mining, Metallurgical & Petroleum Engineers, Electric Furnace Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

Moriarty Again Heads S.F.S.A.

Plans for the immediate future were stressed at the 59th annual meeting of the Steel Founders' Society of America held during March in Chicago. Observance was also made of the steel casting industry's centennial in the United States.

W. H. Moriarty, National Malleable & Steel Castings Co., Cleveland, was re-elected president and Robert M. Schumo, Pennsylvania Electric Steel Castings Co., Hamburg, Pa., was named as vice-president. W. P. Dudley, Ohio Steel Foundry Co., Springfield, Ohio, director of the society's division 5, was elected to serve with Moriarty and Schumo on the executive committee. R. G. Parks, National Malleable & Steel Castings Co., was re-elected treasurer. Erwin Dieckmann, was named secretary.

Other staff members re-elected were: F. Kermit Donaldson, executive vice-president; Charles W. Briggs, technical and research director; and George K. Dreher, market development director.

Advertisers This Issue

The Editor's Forum . . .

Quite likely . . . your problem has already been solved by some other foundryman. In fact it's pretty hard to come up with an absolutely new problem these days. So often when you tell one of your fellow foundrymen about a sand difficulty you can't seem to resolve in your shop he will belittle you by saying, "Hell, Joe, we solved that problem four years ago. Didn't you read the article that ran in MODERN CASTINGS back in 1957 telling how to avoid sand segregation when drawing sand out of a silo? Just use lots of holes uniformly spaced in the bottom of your sand bin. Then when you draw sand out of storage it runs out of all the holes at once, maintaining its uniformity."

What I'm really driving at with this story is the fact that most foundrymen have not learned to use the first basic elementary step in solving a problem—make a literature search. Chances are an article has been published in MODERN CASTINGS, AFS Transactions, or Foundry magazine spelling out all the details for correcting your difficulty. You should have a complete set of annual indexes of articles printed in these publications for the past 10 or more years at your fingertips in a convenient file. Look for articles under the appropriate generic heading such as "aluminum", "melting", "gating & risering", etc. Then read all the articles written on the subject. If you don't find the exact answer to your problem, at least you will have thoroughly informed yourself so you know about all there is to know on the subject. Armed with this background of technology you can intelligently diagnose your troubles and instigate some likely cures.

This beats thrashing around making all the mistakes of your predecessors. Our metalcasting industry owes a great deal of its success to the unselfish foundry technologists who have contributed many dollars and many long hours to solve your problems. They particularly deserve praise for expending additional time to write up their results and share this know-how with the entire industry through published articles.

It behooves the rest of the industry to at least profit from new technology by using it to make better castings. The reputation of metalcastings and the foundry industry are more often established by the failures attributable to decadent practices than the successes arising from modern technology.

Are you wasting your waste products . . . Perhaps you don't realize it, but you can extract a lot of valuable metal from floor sweepings, furnace skimmings, and slag. Canadian Bronze Co. Ltd. has been particularly resourceful in demonstrating how to mine the metal out of your waste products. They run all their foundry residues through a ball mill and then over a flotation table where the metallics are separated from the refractory residues. About 60 per cent of the material processed turns out to be metallic. The metal fines are re-melted and pigged. After the chemical analysis is learned the pigs are added to melts where they are compatable with the ultimate composition desired. If any of your foundrymen have discovered other ways of squeezing the squeal out of foundry by-products why not share it with our MODERN CASTINGS readers. It may help pay some taxes and keep a few more shops in business. Just drop me a line if you have any ideas.

Want to increase your metal yield . . . by reducing weight of risers? Who doesn't? Take a close look at exothermic riser sleeves and hot topping compounds. Their use can reduce riser weight 60 to 70 per cent, reduce riser cut-off time, and increase yield from 60 to 90 per cent of metal melted. If your melting costs are greater than 1.5 cents per pound, chances are you can more than offset the costs of exothermic materials with the savings that result. A shield on top of a riser will keep it molten 50 per cent longer than if riser is open. With both a shield and sleeve, riser will stay molten four times longer than normal riser. You can't afford to pass up such opportunities of applying the new technology for profit.

Jack H Schaum

VOLCLAY BENTONITE

NEWS LETTER No. 73

REPORTING NEWS AND DEVELOPMENTS IN THE FOUNDRY USE OF BENTONITE

BURN-IN OR BURN-ON

Burn-in, or burn-on, is METAL PENETRATION. It is a surface defect occurring from metal entering the voids of the sand mixture.

A rough surface of metal and sand adheres tightly to the casting surface and cannot be readily removed by normal cleaning methods.

Impregnation of sand with metal can be aggravated by many factors: e.g., type of metal, pouring rate, pouring temperature of the metal, molding sand mixture uses, etc., etc.

The illustration is one example of burn-in, or burn-on, caused by lack of molding sand density coupled with high metal ferrostatic pressure.

Excessive water is a strong contributor towards burn-in or burn-on. Excess water may be required to cool hot sands by converting water to steam. This reduces molding sand density. Large additions of cellulose to molding sands absorb excess water and create a bulking effect within the sand mixture.

When hot metal enters such a mold, the cellulose burns, the water converts to steam, **thus larger voids are created!** To reduce burn-in and burn-on penetration we recommend the following:

1. Reduce or eliminate hot sands.
2. Minimize temper water additions.
3. Curtail excess cellulose material; avoid coarse cellulose additives.
4. Add new fine sand to increase molding sand density and refractoriness.
5. Avoid coarse, open base sands.
6. Use Volclay to improve thermal properties.
7. Abstain from high deformation sand mixtures.
8. Eliminate uneven and soft rammed molds.
9. Do not pour too much metal in too small a flask.
10. Use the correct carbon additive (if required) for the sand mixture.

—Write for NEWSLETTER No. 24—"Metal Penetration"

AMERICAN COLLOID COMPANY

SKOKIE, ILLINOIS • *Producers of Volclay and Panther Creek Bentonite*

Circle No. 162, Pages 129-130